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Emission Test Report C. F. Industries Harrison, Tennessee

CA-798

REPORT ON PROCESS EMISSIONS TESTS AT THE CF INDUSTRIES. INC,. AMMONIUM NITRATE FERTILIZER PLANT IN HARRISON, TENNESSEE

Thomas M. Bibb
EPA Project Manager

Clyde E. Riley
EPA Technical Manager

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Willard A. Wade, III, P.E.
Project Manager

Reed W. Cass
Project Engineer

June 25, 1980

TRC-Environmental Consultants, Inc.

Willard A. Wade III, P.E.
Project Manager

June 25, 1980

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PREFACE

The work herein was conducted by personnel from TRC-Environmental Consultants, Inc., (TRC), the GCA/Technology Division (GCA), CF Industries, Inc., (CFI), Harrison, Tennessee, and the U.S. Environmental Protection Agency (EPA).

The scope of the work issued under EPA Contract No. 68-02-2820, Work Assignment No. 12 was under the supervision of the TRC Project Manager, Mr. Willard A. Wade, III. Mr. Reed W. Cass of TRC served as Project Engineer and was responsible for summarizing the test and analytical data in this report. Analysis of the samples was performed at the CFI Harrison, Tennessee plant under the direction of Ms. Margaret Fox and at the TRC labs in Wethersfield, Connecticut under the direction of Ms. Joanne J. Marchese.

Mr. Tim Curtin of GCA was responsible for monitoring the process operations during the testing program. GCA personnel were also responsible for preparing Section 3.0 (Process Description and Operations) and Appendix M of this report.

Members of CF Industries, Inc., Harrison, Tennessee whose assistance and guidance contributed greatly to the success of the test program include Mr. Fred W. Lockemann, Manager Engineering, Mr. John Turner, Process Engineer, and Mr. Richard Westmoreland, Special Problems Chemist.

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

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

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1.0 INTRODUCTION

1.1 Background

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

EPA's Office of Air Quality Planning and Standards (OAQPS) selected the CF Industries, Inc., ammonium nitrate manufacturing plant at Harrison, Tennessee as a site for an emission test program. This plant produces ammonium nitrate for industrial and fertilizer use, and is considered to employ process and emission control technology representative of high density ammonium nitrate solution production, concentration, prilling and rotary drum cooling processes. The test program was designed to provide a portion of the emission data base required for SPNSS for the processes associated with the production of ammonium nitrate.

EPA engaged TRC to measure ammonium nitrate and ammonia concentrations and mass flowrates; particle size distributions; and plume opacities. All measurements made at this facility were performed during times of normal operation of the ammonium nitrate production process, as described in Section 3.0, Process Description and Operations.

The measurement program was conducted at the CF Industries, Inc., ammonium nitrate manufacturing facility in Harrison, Tennessee during the weeks of May 7 through May 11 and June 18 through June 22, 1979. The emissions tests performed May 8 - 11, 1979 were designed to characterize and quantify uncontrolled emissions from the solids production process (Prill Tower and Prill Cooler) and to determine control equipment efficiency. The emissions tests performed June 19 - 22, 1979 were designed to characterize and quantify uncontrolled emissions from the solution production process (neutralizers and evaporators) and to determine emission control efficiency.

1.2 General Process Description

Figure 1-1 presents a flow diagram of the production process, described very basically as follows:

> Nitric acid and ammonia are fed to two parallel neutralizers, from which an 85% ammonia nitrate (AN) solution flows into a common surge tank. The AN solution then passes through a two-stage evaporator where it is concentrated to greater than 99%. A magnesium nitrate additive is added between the first evaporator (Calandria Concentrator) and the second evaporator (Air-Swept Falling-Film Evaporator). The 99+ percent solution is then pumped to the top of the Prill Tower, through which AN droplets fall countercurrent to an induced air flow. The solid prill product is collected at the bottom of the tower and is conveyed to a rotary drum cooler where it is cooled and dried. After screening, correctly-sized prills are conveyed to storage bins.
>
> The air flow through the Prill Tower is directed to a Koch valve tray scrubber. The rotary drum cooler exhaust air stream is divided into two separate streams, each of which enters a separate spray chamber scrubber. The air exiting each spray chamber is again divided into two streams, each of which enters a separate cyclonic separator. The four separator outlets are then combined into two. Emissions vented from each of the neutralizers are driven by the

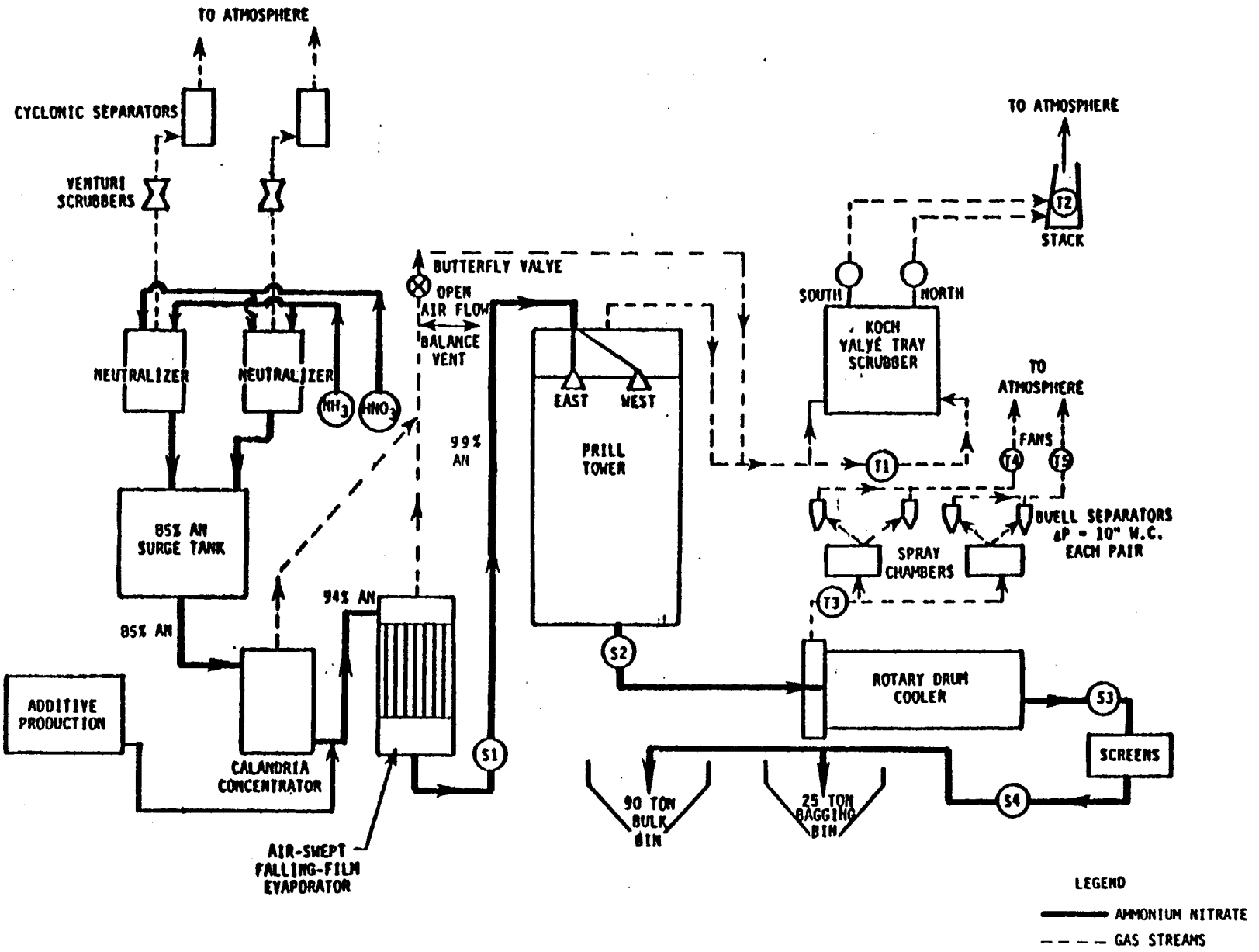

FIGURE 1-1: FLOW DIAGRAM OF AMMONIUM NITRATE PRODUCTION AT C F INDUSTRIES, INC., HARRISON, TENNESSEE

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internal operating pressure of the neutralizers through venturi-cyclonic separator scrubbers. Emissions venting from the evaporators are normally ducted to the Koch valve tray scrubber along with the Prill Tower emissions; for this testing program, however, evaporator emissions were vented directly to the atmosphere.

1.3 Measurement Program

The measurement program was conducted at the CF Industries, Inc., ammonium nitrate manufacturing facility in Harrison, Tennessee, during the weeks of May 7 - 11, and June 18 - 22, 1979. TRC personnel were responsible for sampling and analyzing process emissions; concurrently, GCA was responsible for monitoring pertinent process operation parameters.

Several of the test runs at the neutralizers were discontinuous due to excessive amounts of water in the gas streams. These interruptions are indicated in the Daily Summary Logs contained in Appendix D.

The components of the measuring program were as follows.

1.3.1 Prill Tower Scrubber

Ammonium Nitrate, Ammonia and Magnesium in Gas Stream

Three runs of concurrent inlet and outlet tests were performed in accordance with prescribed EPA methods.

Particle Size Distribution in Gas Stream

Three test runs on the inlet gas stream were performed with a cascade impactor in accordance with the impactor manufacturer's procedures.

Visible Emissions

The opacity of the Prill Tower scrubber exhaust plume was monitored for approximately seven hours during the May testing period.

Scrubber Liquor Evaluation

Samples of the inlet and outlet scrubber liquor were collected periodically during each test run. The temperature and pH of the

samples were measured, and the samples were subsequently analyzed for ammonium nitrate, ammonia and undissolved solids.

Pressure Drop Across Scrubber

The gas pressure drop across the scrubber was measured periodically during each test run.

1.3.2 Prill Cooler Scrubber

Ammonium Nitrate and Ammonia in Gas Stream

Three test runs were performed on the single common inlet to the spray chamber scrubbers and on the two cyclonic separator outlets.

Visible Emissions

The opacities of the two Prill Cooler scrubber system exhaust plumes were monitored simultaneously for three hours during the May testing period.

Particle Size Distribution in Gas Stream

Three test runs on the inlet gas stream were performed with a cascade impactor in accordance with the impactor manufacturer's procedures.

Scrubber Liquor Evaluation

Samples of the common inlet and common outlet scrubber liquor were collected periodically during each test run.

Pressure Drop Across Scrubber

The gas pressure drops across the scrubber (measured with two manometers from the common scrubber system inlet to both of the scrubber system outlets) were measured periodically during each test run.

1.3.3 Neutralizers

Ammonium Nitrate and Ammonia in Gas Streams

Three runs of concurrent inlet and outlet tests were performed on Neutralizer No. 1 scrubber, and three separate runs were performed on the outlet of Neutralizer No. 2 scrubber. EPA test methods for high water-content gas streams were followed.

Visible Emissions

The combined opacity of the two neutralizer scrubber plumes was monitored for three hours during the June test period.

Scrubber Liquor Evaluation

Samples of the Neutralizer No. 1 scrubber inlet liquor were collected periodically during the three test runs.

Pressure Drop Across Scrubber

The gas pressure drop across the Neutralizer No. 1 scrubber was measured periodically during the test runs.

Integrated Gaseous Bag Samples

Bag samples of the Neutralizer No. 1 inlet gas stream were analyzed for CO_2 and O_2. One bag sample was taken during each of the three test runs.

1.3.4 Evaporators

Ammonium Nitrate and Ammonia in Gas Streams

Three test runs on the Calandria outlet and three test runs on the combined Calandria and Air-Swept Falling-Film Evaporator outlet were performed.

1.3.5 Product Sampling and Analysis

Prill Tower

The ammonium nitrate (AN) feed melt to the Prill Tower and the solid AN prills from the tower were sampled and analyzed.

Prill Cooler

The solid AN prills from the cooler before screening were sampled and analyzed.

Neutralizer

The 85% AN feed from Neutralizer No. 1 to the surge tank was sampled and analyzed.

Evaporators

The 85% AN feed from the surge tank to the Calandria, the 94% AN feed from the Calandria to the Air-Swept Falling-Film (ASFF) Evaporator, and the 99% AN feed from the ASFF evaporator to the Prill Tower were sampled and analyzed.

1.3.6 Ambient Air Measurements

Ambient air temperature, relative humidity and barometric pressure measurements were taken periodically during the Prill Tower, Prill Cooler, Neutralizer and Evaporator test runs. Measurements were made in the immediate vicinity of the process involved.

1.3.7 Clean-up Evaluation and Audit Samples

The sampling train was assembled and charged as if ready to perform a test for ammonium nitrate (AN) and ammonia. The unexposed impinger contents were then recovered, prepared and analyzed according to procedure in order to establish background/contamination levels of AN and ammonia.

Audit samples from EPA and from CFI were analyzed for ammonia and nitrate after both the May and June testing periods in order to assess the accuracy of the analysis procedures.

1.4 Description of Report Sections

The remaining sections of this report cover Summary of Results (Section 2.0), Process Description and Operations (Section 3.0), Location of Sampling Points (Section 4.0), and Sampling and Analytical Methods (Section 5.0). Descriptions of methods and procedures, field and laboratory data, and calculations are presented in the various appendices, as noted in the Table of Contents. Appendix R contains the results of the clean-up evaluations performed on the sampling train equipment, and Appendix Q contains the results of audit sample analyses.

2.0 SUMMARY OF RESULTS

This section presents the results of emissions tests performed at the CF Industries Inc., Harrison, Tennessee, ammonium nitrate manufacturing plant in May and June 1979. During this testing program, the gas and water streams entering and exiting the prill tower scrubber, prill cooler scrubber and neutralize scrubbers, and the gas streams from the Calandria and air-swept falling-film evaporators, were sampled and analyzed. The process product was also sampled periodically during the emissions tests and analyzed.

2.1 Prill Tower Scrubber

The ammonium nitrate and insoluble particulate measurements made on the prill tower scrubber inlet and outlet gas stream samples are shown in Tables 2-1 (combined inlet and outlet), 2-2 (inlet) and 2-3 (outlet). The average total particulate (ammonium nitrate plus insoluble particulate) removal efficiency is 46.9 percent.

The ammonia measurements made on the inlet and outlet gas stream samples are shown in Tables 2-4 (combined inlet and outlet), 2-5 (inlet) and 2-6 (outlet). The average ammonia removal efficiency is 83.7 percent. Tables 2-5 and 2-6 also show a parameter labelled excess ammonia. Assuming that nitrate is the limiting factor in the conversion of ammonia and nitric acid to ammonium nitrate, excess ammonia is calculated by subtracting the ammonia (presumably) combined with the measured nitrate from the total measured ammonia.

The anomalously low ammonia measurements in Run 3 are probably due to the fact that the ammonia injection mechanism on the prill tower was off during this run. Consequently the Run 3 ammonia data are not included in the averages.

TABLE 2-1a (ENGLISH)

SUMMARY OF AMMONIUM NITRATE AND INSOLUBLE PARTICULATE MEASUREMENTS
ON GASES ENTERING AND EXITING THE PRILL TOWER SCRUBBER
AT C F INDUSTRIES, INC., HARRISON, TENNESSEE

RUN NUMBER	RUN 1		RUN 2		RUN 3		AVERAGE	
DATE	05-08-79		05-08-79		05-09-79			
LOCATION	INLET	OUTLET	INLET	OUTLET	INLET	OUTLET	INLET	OUTLET
VOLUME OF GAS SAMPLED (DSCF)[a]	65.7	101.7	64.42	104.1	65.86	98.95	65.33	101.58
PERCENT MOISTURE BY VOLUME	2.049	3.033	2.466	2.56	2.542	2.874	2.352	2.822
AVERAGE STACK TEMPERATURE (^{O}F)	93	96	91	95	91	91	92	94
STACK VOLUMETRIC FLOWRATE (DSCFM)[b]	257800	265200	253900	263700	258500	268500	256700	265800
PERCENT ISOKINETIC	99.3	108.4	98.9	110.8	99.3	103.5	99.2	107.6
PERCENT OPACITY		12.8		15.2		17.2		15.1
PRODUCTION RATE (TONS/HOUR)	21.0	21.0	21.0	21.0	21.3	21.3	21.1	21.1
INSOLUBLE PARTICULATE								
Total Sample Weight (Milligrams)	12.79	5.52	4.97	11.47	0.52	1.95	6.09	6.31
Grains/DSCF	0.003004	0.000837	0.001191	0.001700	0.000122	0.000304	0.001439	0.000959
Pounds/hour	6.638	1.904	2.592	3.842	0.270	0.700	3.165	2.184
Pounds/Ton	0.3161	0.0907	0.1234	0.1830	0.0127	0.0329	0.1500	0.1035
Collection Efficiency (Percent)		71.3		<0		<0		31.0
AMMONIUM NITRATE PARTICULATE[c]								
Total Sample Weight (Milligrams)	133.52	101.14	124.36	101.55	134.81	106.30	130.90	103.00
Grains/DSCF	0.03136	0.01535	0.02979	0.01506	0.03159	0.01658	0.03092	0.01565
Pounds/Hour	69.29	34.88	64.83	34.02	69.99	38.16	68.02	35.64
Pounds/Ton	3.299	1.661	3.087	1.620	3.286	1.792	3.224	1.688
Collection Efficiency (Percent)		49.7		47.5		45.5		47.6
TOTAL PARTICULATE: INSOLUBLE & AMMONIUM NITRATE								
Total Sample Weight (Milligrams)	146.31	106.66	129.33	113.02	135.33	108.25	136.99	109.31
Grains/DSCF	0.03436	0.01618	0.03097	0.01675	0.03171	0.01688	0.03236	0.01661
Pounds/Hour	75.93	36.78	67.42	37.85	70.26	38.85	71.19	37.82
Pounds/Ton	3.615	1.752	3.210	1.802	3.299	1.824	3.378	1.793
Collection Efficiency (Percent)		51.6		43.9		44.7		46.9

a Dry standard cubic feet @ 68^{O}F, 29.92 inches Hg
b Dry standard cubic feet per minute
c Specific ion electrode analysis method. This method measures nitrate (NO_3^-); Ammonium Nitrate (mg) = Nitrate (mg) X 80/62.

TABLE 2-1b (Metric)

SUMMARY OF AMMONIUM NITRATE AND INSOLUBLE PARTICULATE MEASUREMENTS
ON GASES ENTERING AND EXITING THE PRILL TOWER SCRUBBER
AT C F INDUSTRIES, INC.,
HARRISON, TENNESSEE

RUN NUMBER	Run 1		Run 2		Run 3		Average	
DATE	05-08-79		05-08-79		05-09-79			
LOCATION	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet
VOLUME OF GAS SAMPLED (DN m^3)[a]	1.861	2.880	1.824	2.948	1.865	2.802	1.850	2.877
PERCENT MOISTURE BY VOLUME	2.049	3.033	2.466	2.56	2.542	2.874	2.352	2.822
AVERAGE STACK TEMPERATURE (^oC)	34	36	33	35	33	33	33	35
STACK VOLUMETRIC FLOWRATE (DN m^3/min)[b]	7300	7510	7190	7470	7320	7600	7270	7530
PERCENT ISOKINETIC	99.3	108.4	98.9	110.8	99.3	103.5	99.2	107.6
PERCENT OPACITY		12.8		15.2		17.2		15.1
PRODUCTION RATE (Mg/Hour)	19.1	19.1	19.1	19.1	19.3	19.3	19.2	19.2
INSOLUBLE PARTICULATE								
Total Sample Weight (Milligrams)	12.79	5.52	4.97	11.47	0.52	1.95	6.09	6.31
Grams/DN m^3	0.006873	0.001916	0.002725	0.003890	0.000279	0.000696	0.00329	0.00219
Kg/Hour	3.011	0.864	1.176	1.743	0.122	0.318	1.436	0.991
Kg/Mg	0.1581	0.0454	0.0617	0.0915	0.0064	0.0165	0.0750	0.0518
Collection Efficiency (Percent)	71.3		<0		<0		31.0	
AMMONIUM NITRATE PARTICULATE[c]								
Total Sample Weight (Milligrams)	133.52	101.14	124.36	101.55	134.81	106.30	130.90	103.00
Grams/DN m^3	0.07175	0.03512	0.06816	0.03446	0.07228	0.03794	0.07075	0.03585
Kg/Hour	31.43	15.82	29.41	15.43	31.75	17.31	30.86	16.16
Kg/Mg	1.650	0.831	1.544	0.811	1.643	0.896	1.612	0.844
Collection Efficiency (Percent)	49.7		47.5		45.5		47.6	
TOTAL PARTICULATE: INSOLUBLE & AMMONIUM NITRATE								
Total Sample Weight (Milligrams)	146.31	106.66	129.33	113.02	135.33	108.25	136.99	109.31
Grams/DN m^3	0.07862	0.03702	0.07086	0.03832	0.07256	0.03862	0.07404	0.03801
Kg/Hour	34.44	16.68	30.58	17.17	31.87	17.62	32.29	17.16
Kg/Mg	1.808	0.876	1.605	0.902	1.650	0.912	1.689	0.896
Collection Efficiency (Percent)	51.6		43.9		44.7		47.6	

a Dry normal cubic meters @ 20°C, 760 mm Hg.

b Dry normal cubic meters per minute.

c Specific Ion Electrode Analysis method. This method measures nitrate (NO_3-); Ammonium Nitrate (mg) = Nitrate (mg) x 80/62.

TABLE 2-2

SUMMARY OF AMMONIUM NITRATE AND INSOLUBLE PARTICULATE MEASUREMENTS
ON GASES ENTERING THE PRILL TOWER SCRUBBER AT
C F INDUSTRIES, INC., HARRISON, TENNESSEE

RUN NUMBER	RUN 1	RUN 2	RUN 3	AVERAGE
DATE	05-08-79	05-08-79	05-09-79	
VOLUME OF GAS SAMPLED (DSCF)[a]	65.70	64.42	65.86	65.33
PERCENT MOISTURE BY VOLUME	2.049	2.466	2.542	2.352
AVERAGE STACK TEMPERATURE (^{O}F)	93	91	91	92
STACK VOLUMETRIC FLOW RATE (DSCFM)[b]	257,800	253,900	258,500	256,700
PERCENT ISOKINETIC	99.3	98.9	99.3	99.2
PRODUCTION RATE (TONS/HOUR)	21.0	21.0	21.3	21.1
INSOLUBLE PARTICULATE				
Total Sample Weight (Milligrams)	12.79	4.97	0.52	6.09
Grains/DSCF	0.003004	0.001191	0.000122	0.001439
Pounds/Hour	6.638	2.592	0.270	3.165
Pounds/Ton				
AMMONIUM NITRATE PARTICULATE[c]				
Total Sample Weight (Milligrams)	133.52	124.36	134.81	130.90
Grains/DSCF	0.03136	0.02979	0.03159	0.03092
Pounds/Hour	69.29	64.83	69.99	68.02
Pounds/Ton	3.299	3.087	3.286	3.224
TOTAL PARTICULATE: INSOLUBLE AND AMMONIUM NITRATE				
Total Sample Weight (Milligrams)	146.31	129.33	135.33	136.99
Grains/DSCF	0.03436	0.03077	0.03171	0.03236
Pounds/Hour	75.93	67.42	70.26	71.19
Pounds/Ton	3.615	3.210	3.299	3.378
PERCENT PARTICULATE CATCH*	8.7	3.8	0.38	4.4

[a] Dry standard cubic feet @ 68^{O}F, 29.92 inches Hg.

[b] Dry standard cubic feet per minute @ 68^{O}F, 29.92 inches Hg.

[c] Specific Ion Electrode analysis method. This method measures nitrate (NO_3-); Ammonium nitrate (mg) = nitrate (mg) X 80/62.

* (Insoluble Particulate/Total Particulate) X 100.

TABLE 2-3

SUMMARY OF AMMONIUM NITRATE AND INSOLUBLE PARTICULATE MEASUREMENTS
ON GASES EXITING THE PRILL TOWER SCRUBBER AT
C F INDUSTRIES, INC., HARRISON, TENNESSEE

RUN NUMBER	RUN 1	RUN 2	RUN 3	AVERAGE
DATE	05-08-79	05-08-79	05-09-79	
VOLUME OF GAS SAMPLED (DSCF)[a]	101.70	104.10	98.95	101.58
PERCENT MOISTURE BY VOLUME	3.033	2.560	2.874	2.822
AVERAGE STACK TEMPERATURE (^{O}F)	96	95	91	94
STACK VOLUMETRIC FLOW RATE (DSCFM)[b]	265200	263700	268500	265800
PERCENT ISOKINETIC	108.4	110.8	103.5	107.6
PRODUCTION RATE (TONS/HOUR)	21.0	21.0	21.3	21.1
INSOLUBLE PARTICULATE				
Total Sample Weight (Milligrams)	5.52	11.47	1.95	6.31
Grains/DSCF	0.000837	0.001700	0.000304	0.000959
Pounds/Hour	1.904	3.842	0.700	2.184
Pounds/Ton	0.0907	0.1830	0.0329	0.1035
AMMONIUM NITRATE PARTICULATE[c]				
Total Sample Weight (Milligrams)	101.14	101.55	106.30	103.00
Grains/DSCF	0.01535	0.01506	0.01658	0.01565
Pounds/Hour	34.88	34.02	38.16	35.64
Pounds/Ton	1.661	1.620	1.792	1.688
TOTAL PARTICULATE: INSOLUBLE AND AMMONIUM NITRATE				
Total Sample Weight (Milligrams)	106.66	113.02	108.25	109.31
Grains/DSCF	0.01618	0.01675	0.01688	0.01661
Pounds/Hour	36.78	37.85	38.85	37.82
Pounds/Ton	1.752	1.802	1.824	1.793
PERCENT PARTICULATE CATCH *	5.2	10.1	1.8	5.8

[a] Dry standard cubic feet @ 68^{O}F, 29.92 inches Hg.

[b] Dry standard cubic feet per minute @ 68^{O}F, 29.92 inches Hg.

[c] Specific Ion Electrode analysis method. This method measures nitrate (NO_3-); ammonium nitrate (mg) = nitrate (mg) X 80/62.

* (Insoluble Particulate/Total Particulate) X 100.

TABLE 2-4a (English)

SUMMARY OF AMMONIA AND CALCULATED AMMONIUM NITRATE MEASUREMENTS ON GASES ENTERING AND EXITING THE PRILL TOWER SCRUBBER AT C F INDUSTRIES, INC., HARRISON, TENNESSEE

RUN NUMBER	Run 1		Run 2		Run 3		Average[e]	
DATE	05-08-79		05-08-79		05-09-79			
LOCATION	INLET	OUTLET	INLET	OUTLET	INLET	OUTLET	INLET	OUTLET
VOLUME OF GAS SAMPLED (DSCF)[a]	65.70	101.70	64.42	104.10	65.86	98.95	65.33	101.58
PERCENT MOISTURE BY VOLUME	2.049	3.033	2.466	2.560	2.542	2.874	2.352	2.822
AVERAGE STACK TEMPERATURE (^{o}F)	93	96	91	95	91	91	92	94
STACK VOLUMETRIC FLOWRATE (DSCFM)[b]	257,800	265,200	253,900	263,700	258,500	268,500	256,700	265,800
PERCENT ISOKINETIC	99.30	108.4	98.86	110.8	99.25	103.5	99.14	107.6
PRODUCTION RATE (TONS/HOUR)	21.0	21.0	21.0	21.0	21.3	21.3	21.2	21.2
AMMONIA DATA[c]								
Total Sample Weight (Milligrams)	2372	593	2330	554	114.5	199.4	2351	574
Grains/DSCF	0.55715	0.08998	0.55816	0.08212	0.02683	0.03110	0.55535	0.08720
Pounds/Hour	1231.1	204.5	1214.7	185.6	59.4	71.6	1221.8	198.7
Pounds/Ton	58.62	9.74	57.85	8.84	2.79	3.36	57.63	9.40
Collection Efficiency (Percent)		83.4		84.7		<0		83.7
AMMONIUM NITRATE CALCULATED FROM AMMONIA[d]								
Total Sample Weight (Milligrams)	11162	2791	10965	2607	539	938	11064	2701
Grains/DSCF	2.6218	0.4235	2.6267	0.3865	0.1263	0.1463	2.6135	0.4104
Pounds/Hour	5793.4	962.7	5716.5	873.7	279.8	336.7	5749.5	934.9
Pounds/Ton	275.9	45.8	272.2	41.60	13.1	15.8	271.2	44.15
Collection Efficiency (Percent)		83.4		84.7		<0		83.7

a Dry standard cubic feet @ 68^{o}F, 29.92 inches Hg.

b Dry standard cubic feet per minute.

c Specific Ion Electrode analysis method.

d Ammonium nitrate (mg) = Ammonia (mg) x 80/17.

e Ammonia and Ammonium nitrate averages include only Runs 1 and 2.

TABLE 2-4b (Metric)

SUMMARY OF AMMONIA AND CALCULATED AMMONIUM NITRATE MEASUREMENTS
ON GASES ENTERING AND EXITING THE PRILL TOWER SCRUBBER
AT C F INDUSTRIES, INC.,
HARRISON, TENNESSEE

RUN NUMBER	RUN 1		RUN 2		RUN 3		AVERAGE[c]	
DATE	05-08-79		05-08-79		05-09-79			
LOCATION	INLET	OUTLET	INLET	OUTLET	INLET	OUTLET	INLET	OUTLET
VOLUME OF GAS SAMPLED (DNm^3)[a]	1.861	2.880	1.824	2.948	1.865	2.802	1.850	2.877
PERCENT MOISTURE BY VOLUME	2.049	3.033	2.466	2.560	2.542	2.874	2.352	2.822
AVERAGE STACK TEMPERATURE (^oC)	34	36	33	35	33	33	33	35
STACK VOLUMETRIC FLOWRATE (DNm^3/min)[b]	7300	7510	7190	7470	7320	7600	7270	7530
PERCENT ISOKINETIC	99.3	108.4	98.9	110.8	99.3	103.5	99.1	107.6
PRODUCTION RATE (Mg/Hour)	19.1	19.1	19.1	19.1	19.3	19.3	19.2	19.2
AMMONIA DATA[c]								
Total Sample Weight (Milligrams)	2372	593	2330	554	114.5	199.4	2351	574
Grams/DNm^3	1.275	0.2059	1.277	0.1879	0.06139	0.07116	1.271	0.1995
Kg/Hour	558.4	92.76	551.0	84.21	26.94	32.48	554.2	90.12
Kg/Mg	29.31	4.87	28.92	4.42	1.40	1.68	28.82	4.69
Collection Efficiency (Percent)	83.4		84.7		<0		83.7	
AMMONIUM NITRATE CALCULATED FROM AMMONIA[d]								
Total Sample Weight (Milligrams)	11162	2791	10965	2607	539	938	11064	2701
Grams/DNm^3	5.999	0.9690	6.010	0.8843	0.2890	0.3347	5.980	0.9389
Kg/Hour	2628	436.7	2593	396.3	126.9	152.7	2608	424.1
Kg/Mg	137.95	22.9	136.11	20.80	6.55	7.9	135.6	22.07
Collection Efficiency (Percent)	83.4		84.7		<0		83.7	

[a] Dry normal cubic meters @ 20°C, 760 mm Hg.

[b] Dry normal cubic meters per minute.

[c] Specific Ion Electrode Analysis method.

[d] Ammonium nitrate (mg) = Ammonia (mg) X 80/17.

[e] Ammonia and ammonium nitrate averages include only Runs 1 and 2.

TABLE 2-5

SUMMARY OF AMMONIA, CALCULATED AMMONIUM NITRATE AND CALCULATED EXCESS AMMONIA MEASUREMENTS
ON GASES ENTERING THE PRILL TOWER SCRUBBER AT
C F INDUSTRIES, INC., HARRISON, TENNESSEE

RUN NUMBER	RUN 1	RUN 2	RUN 3	AVERAGE [f]
DATE	05-08-79	05-08-79	05-08-79	
VOLUME OF GAS SAMPLED (DSCF) [a]	65.70	64.42	65.86	65.33
STACK VOLUMETRIC FLOW RATE (DSCFM) [b]	257800	253900	258500	256700
PRODUCTION RATE (TONS/HOUR)	21.0	21.0	21.3	21.1
AMMONIA [c]				
Total Sample Weight (Milligrams)	2372	2330	114.5	2351
Grains (DSCF)	0.55715	0.55816	0.02683	0.55535
Pounds/Hour	1231.1	1214.7	59.4	1221.8
Pounds/Ton	58.62	57.85	2.79	57.63
AMMONIUM NITRATE CALCULATED FROM AMMONIA [d]				
Total Sample Weight (Milligrams)	11162	10965	539	11064
Grains/DSCF	2.6218	2.6267	0.1263	2.6135
Pounds/Hour	5793	5716	280	5749
Pounds/Ton	275.9	272.2	13.1	271.2
EXCESS AMMONIA [e]				
Total Sample Weight (Milligrams)	2344	2304	85.8	2323
Grains/DSCF	0.5506	0.5520	0.0201	0.5488
Pounds/Hour	1217	1202	44.55	1207
Pounds/Ton	57.95	57.22	2.092	57.21

[a] Dry standard cubic feet @ 68°F, 29.92 inches Hg.

[b] Dry standard cubic feet per minute @ 68°F, 29.92 inches Hg.

[c] Specific Ion Electrode analysis method.

[d] Ammonium nitrate (mg) = ammonia (mg) X 80/17.

[e] Excess Ammonia = {(Ammonium nitrate calculated from ammonia) - (Ammonium nitrate measured directly, from Table 2-2)} X 17/80.

[f] Ammonia, calculated ammonium nitrate and excess ammonia averages are calculated from Runs 1 and 2 only.

TABLE 2-6

SUMMARY OF AMMONIA, CALCULATED AMMONIUM NITRATE AND CALCULATED EXCESS AMMONIA MEASUREMENTS ON GASES EXITING THE PRILL TOWER SCRUBBER AT C F INDUSTRIES, INC., HARRISON, TENNESSEE

RUN NUMBER	RUN 1		RUN 2		RUN 3		AVERAGE [g]	
DATE	05-08-79		05-08-79		05-09-79			
VOLUME OF GAS SAMPLED (DSCF) [a]	101.70		104.10		98.95		101.58	
STACK VOLUMETRIC FLOW RATE (DSCFM) [b]	265200		263700		268500		265800	
PRODUCTION RATE (TONS/HOUR)	21.0		21.0		21.3		21.1	
AMMONIA	SIE [c]	NESSLER [d]	SIE	NESSLER	SIE	NESSLER	SIE	NESSLER
Total Sample Weight (Milligrams)	593	552	554	473	199.4	204.6	574	513
Grains/DSCF	0.08998	0.08376	0.08212	0.07012	0.03110	0.03191	0.08720	0.07794
Pounds/Hour	204.5	190.4	185.6	158.4	71.6	73.4	198.7	177.6
Pounds/Ton	9.74	9.07	8.84	7.54	3.36	3.45	9.40	8.38
AMMONIUM NITRATE CALCULATED FROM AMMONIA [e]								
Total Sample Weight (Milligrams)	2791	2598	2607	2226	938	963	2701	2414
Grains/DSCF	0.4235	0.3942	0.3865	0.3300	0.1463	0.1502	0.4104	0.3667
Pounds/Hour	962.7	896.1	873.7	745.9	336.7	345.7	934.9	835.5
Pounds/Ton	45.8	42.7	41.6	35.5	15.8	16.2	44.15	39.4
EXCESS AMMONIA [f]								
Total Sample Weight (Milligrams)	572	531	532	456	177	182	552	492
Grains/DSCF	0.08680	0.08057	0.07886	0.06760	0.02760	0.02838	0.08386	0.07475
Pounds/Hour	197.3	182.2	178.3	152.8	63.53	65.32	191.1	170.3
Pounds/Ton	9.40	8.72	8.48	7.28	2.98	3.07	9.05	8.07

[a] Dry standard cubic feet @ 68°F, 29.92 inches Hg.

[b] Dry standard cubic feet per minute @ 68°F, 29.92 inches Hg.

[c] Specific Ion Electrode analysis method.

[d] Nessler (with preliminary distillation) analysis method.

[e] Ammonium nitrate (mg) = Ammonia (mg) X 80/17.

[f] Excess Ammonia = ((Ammonium nitrate calculated from ammonia) - (Ammonium nitrate measured directly, from Table 2-3)) X 17/80.

[g] Ammonia, calculated ammonium nitrate and excess ammonia averages are based on Runs 1 and 2 only.

The magnesium measurements made on the inlet and outlet gas streams are shown in Table 2-7. The average magnesium removal efficienty is 72.4 percent.

The scrubber outlet samples were analyzed for ammonia by the specific ion electrode (SIE) method and the Nessler method. The SIE analyses were done at the CFI laboratory within 48 hours after samples were taken and the Nessler analyses were done at TRC within 10 days of sampling. For this reason, and to facilitate comparisons with inlet data resulting from SIE analyses alone, the SIE ammonia data are considered the primary data for all data presented in Section 2.0. Discussions of all analysis methods are contained in Section 5.0, Sampling and Analysis Methods.

The isokinetic percentages for the prill tower scrubber outlet test runs 1 and 2 are relatively high (108% and 111% respectively). The reasons for this are not evident and can probably be attributed to a contistent operator error. The effect on the amount of particulate matter sampled is not considered significant.

2.2 Prill Cooler Scrubber

The ammonium nitrate and insoluble particulate measurements made on the prill cooler scrubber inlet and two outlets are shown in Tables 2-8 (inlet and combined outlets) 2-9 (inlet) and 2-10 (each outlet). Because the flow rates in the two scrubber outlet stacks were not equal to each other, averages weighted by flowrate were calculated for some combined outlet parameters shown in Table 2-8. The average total particulate removal efficiency was 90.3 percent.

TABLE 2-7a (ENGLISH)

SUMMARY OF MAGNESIUM MEASUREMENTS ON GASES
ENTERING AND EXITING THE PRILL TOWER SCRUBBER
AT C F INDUSTRIES, INC.,
HARRISON, TENNESSEE

RUN NUMBER	RUN 1		RUN 2		RUN 3		AVERAGE	
DATE	05-08-79		05-08-79		05-09-79			
LOCATION	INLET	OUTLET	INLET	OUTLET	INLET	OUTLET	INLET	OUTLET
VOLUME OF GAS SAMPLED (DSCF)[a]	65.70	101.70	64.42	104.10	65.86	98.95	65.33	101.58
STACK VOLUMETRIC FLOWRATE (DSCFM)[b]	257800	265200	253900	263700	258500	268500	256700	265800
PRODUCTION RATE (TONS/HOUR)	21.0	21.0	21.0	21.0	21.3	21.3	21.1	21.1
TOTAL MAGNESIUM[c]								
Total Sample Weight (Milligrams)	1.164	0.3204	0.3826	0.1856	0.4958	0.3345	0.6808	0.2802
Grains/DSCF	0.0002734	0.00004862	0.00009165	0.00002751	0.0001162	0.00005217	0.0001596	0.00004256
Pounds/Hour	0.6041	0.1105	0.1995	0.06218	0.25747	0.12007	0.35116	0.09696
Pounds/Ton	0.02877	0.00526	0.00950	0.00296	0.01209	0.00564	0.01664	0.00460
Collection Efficiency (Percent)	81.7		68.8		53.3		72.4	

a Dry standard cubic feet @ 68°F, 29.92 inches Hg

b Dry standard cubic feet per minute

c Analyzed by atomic absorption

TABLE 2-7b (Metric)

SUMMARY OF MAGNESIUM MEASUREMENTS ON GASES
ENTERING AND EXITING PRILL TOWER SCRUBBER
AT C F INDUSTRIES, INC.,
HARRSION, TENNESSEE

RUN NUMBER	Run 1		Run 2		Run 3		Average	
DATE	05-08-79		05-08-79		05-09-79			
LOCATION	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet
VOLUME OF GAS SAMPLED (DN m^3)[a]	1.861	2.880	1.824	2.948	1.865	2.802	1.850	2.877
STACK VOLUMETRIC FLOWRATE (DN m^3/min)[b]	7300	7510	7190	7470	7320	7600	7270	7530
PRODUCTION RATE (Mg/Hour)	19.1	19.1	19.1	19.1	19.3	19.3	19.2	19.2
TOTAL MAGNESIUM[c]								
Total Sample Weight (Milligrams)	1.164	0.3204	0.3826	0.1856	0.4958	0.3345	0.6808	0.2802
Grams/DN m^3	0.0006256	0.0001113	0.0002097	0.00006295	0.0002659	0.0001194	0.0003652	0.0000974
Kg/Hour	0.2740	0.0501	0.0905	0.0282	0.1168	0.0545	0.1593	0.0440
Kg/Mg	0.01438	0.00263	0.00475	0.00148	0.00605	0.00282	0.00832	0.00230
Collection Efficiency (Percent)	81.7		68.8		53.3		72.4	

a Dry normal cubic meters @ 20°C, 760 mm Hg

b Dry normal cubic meters per minute

c Analyzed by atomic absorption

TABLE 2-8a (ENGLISH)

SUMMARY OF AMMONIUM NITRATE AND INSOLUBLE PARTICULATE MEASUREMENTS
ON GASES ENTERING AND EXITING THE PRILL COOLER SCRUBBER
AT C F INDUSTRIES, INC., HARRISON, TENNESSEE

RUN NUMBER	RUN 1		RUN 2		RUN 3		AVERAGE	
DATE	5-10-79		5-11-79		5-11-79			
LOCATION	INLET	COMBINED OUTLET	INLET	COMBINED OUTLET	INLET	COMBINED OUTLET	INLET	COMBINED OUTLET
VOLUME OF GAS SAMPLE (DSCF)[a]	52.35	174.30	51.63	174.58	50.72	170.50	51.57	173.12
PERCENT MOISTURE BY VOLUME*	1.879	2.290	1.447	3.182	0.755	2.428	1.360	2.634
AVERAGE STACK TEMPERATURE (^{o}F)*	143	118	144	114	145	118	144	117
STACK VOLUMETRIC FLOWRATE (DSCFM)[b]	31650	34410	31120	33660	31020	33140	31260	33740
PERCENT ISOKINETIC	99.3	97.8	99.6	100.7	98.2	101.7	99.0	100.1
PRODUCTION RATE (TONS/HOUR)	21.0	21.0	21.0	21.0	20.7	20.7	20.9	20.9
INSOLUBLE PARTICULATE								
Total Sample Weight (Milligrams)	5.08	7.83	2.46	6.62	4.44	20.10	3.99	11.52
Grains/DSCF*	0.00150	0.000581	0.000735	0.000462	0.00135	0.00173	0.00119	0.000918
Pounds/Hour	0.4063	0.1714	0.1961	0.1333	0.3592	0.4914	0.3199	0.2655
Pounds/Ton	0.0193	0.00816	0.00934	0.00634	0.01735	0.02374	0.01531	0.01270
Collection Efficiency (Percent)		57.7		32.1		<0		17.0
AMMONIUM NITRATE PARTICULATE[c]								
Total Sample Weight (Milligrams)	415.4	94.94	407.6	149.90	472.1	71.72	431.7	105.52
Grains/DSCF*	0.1225	0.00971	0.1218	0.01579	0.1436	0.00673	0.1292	0.01078
Pounds/Hour	33.22	2.864	32.50	4.556	38.19	1.912	34.62	3.118
Pounds/Ton	1.582	0.1364	1.547	0.2169	1.845	0.09235	1.656	0.1492
Collection Efficiency (Percent)		91.4		86.0		95.0		91.0
TOTAL PARTICULATE: INSOLUBLE & AMMONIUM NITRATE								
Total Sample Weight (Milligrams)	420.48	102.77	410.06	156.52	476.54	91.82	435.69	117.04
Grains/DSCF*	0.1240	0.01029	0.1226	0.01625	0.1450	0.00846	0.1304	0.01170
Pounds/Hour	33.63	3.035	32.69	4.688	38.55	2.403	34.94	3.384
Pounds/Ton	1.601	0.1445	1.557	0.2233	1.862	0.1161	1.672	0.1619
Collection Efficiency (Percent)		91.0		85.7		93.8		90.3

a Dry standard cubic feet @ 68^{o}F, 29.92 inches Hg

b Dry standard cubic feet per minute

c Specific ion electrode analysis method. This method measures Nitrate (NO_3^-); Ammonium Nitrate (mg) = Nitrate (mg) x 80/62.

* Combined outlet values are weighted averages (weighted by flowrate). Separate outlet values are shown in Table 2-10.

TABLE 2-8b (Metric)

SUMMARY OF AMMONIUM NITRATE AND INSOLUBLE PARTICULATE MEASUREMENTS ON GASES ENTERING AND EXITING THE PRILL COOLER SCRUBBER AT C F INDUSTRIES, INC., HARRISON, TENNESSEE

RUN NUMBER	Run 1		Run 2		Run 3		Average	
DATE	05-10-79		05-11-79		05-11-79			
LOCATION	Inlet	Combined Outlets	Inlet	Combined Outlets	Inlet	Combined Outlets	Inlet	Combined Outlets
VOLUME OF GAS SAMPLED (DN m^3)[a]	1.483	4.936	1.462	4.944	1.436	4.829	1.460	4.903
PERCENT MOISTURE BY VOLUME*	1.879	2.290	1.447	3.182	0.755	2.428	1.360	2.634
AVERAGE STACK TEMPERATURE (^oC)*	62	48	63	46	63	48	63	48
STACK VOLUMETRIC FLOWRATE (DN m^3/min)[b]	896	974	881	953	878	939	885	956
PERCENT ISOKINETIC	99.3	97.8	99.6	100.7	98.2	101.7	99.0	100.1
PRODUCTION RATE (Mg/Hour)	19.1	19.1	19.1	19.1	18.8	18.8	19.0	19.0
INSOLUBLE PARTICULATE								
Total Sample Weight (Milligrams)	5.08	7.83	2.46	6.62	4.44	20.10	3.99	11.52
Grams/DN m^3*	0.00343	0.001329	0.001682	0.001057	0.00309	0.00396	0.00272	0.002101
Kg/Hour	0.1843	0.0777	0.0890	0.0605	0.1629	0.2229	0.1451	0.1204
Kg/Mg	0.00965	0.00408	0.00467	0.00317	0.00868	0.01187	0.00766	0.00635
Collection Efficiency (Percent)	57.7		32.1		<0		17.0	
AMMONIUM NITRATE PARTICULATE[c]								
Total Sample Weight (Milligrams)	415.4	94.94	407.6	149.90	472.1	71.72	431.7	105.52
Grams/DN m^3 *	0.2803	0.02222	0.2787	0.03613	0.3286	0.01540	0.2956	0.02467
Kg/Hour	15.07	1.299	14.74	2.067	17.32	0.867	15.70	1.414
Kg/Mg	0.791	0.0682	0.774	0.1085	0.923	0.04618	0.828	0.0746
Collection Efficiency (Percent)	91.4		86.0		95.0		91.0	
TOTAL PARTICULATE: INSOLUBLE AND AMMONIUM NITRATE								
Total Sample Weight (Milligrams)	420.48	102.77	410.06	156.52	476.54	91.82	435.69	117.04
Grams/DN m^3*	0.2837	0.02354	0.2805	0.03718	0.3318	0.01936	0.2984	0.02677
Kg/Hour	15.25	1.377	14.83	2.126	17.49	1.090	15.85	1.535
Kg/Mg	0.801	0.0723	0.779	0.1117	0.931	0.0581	0.836	0.0810
Collection Efficiency (Percent)	91.0		85.7		93.8		90.3	

a Dry normal cubic meters @ 20°C, 760 mm Hg

b Dry normal cubic meters per minute

c Specific Ion Electrode Analysis method. This method measures nitrate (NO_3^-); ammonium nitrate (mg) = nitrate (mg) x 80/62.

* Combined outlet values are weighted averages (weighted by flowrate). Separate outlet values are shown in Table 2-10.

TABLE 2-9

SUMMARY OF AMMONIUM NITRATE AND INSOLUBLE PARTICULATE MEASUREMENTS
ON GASES ENTERING THE PRILL COOLER SCRUBBER
AT C F INDUSTRIES, INC.,
HARRISON, TENNESSEE

RUN NUMBER	RUN 1	RUN 2	RUN 3	AVERAGE
DATE	05-10-79	05-11-79	05-11-79	
VOLUME OF GAS SAMPLED (DSCF) [a]	52.35	51.63	50.72	51.57
PERCENT MOISTURE BY VOLUME	1.879	1.447	0.755	1.360
AVERAGE STACK TEMPERATURE (^{o}F)	143	144	145	144
STACK VOLUMETRIC FLOW RATE (DSCFM) [b]	31650	31120	31020	31260
PERCENT ISOKINETIC	99.3	99.6	98.2	99.0
PRODUCTION RATE (Tons/Hour)				
INSOLUBLE PARTICULATE				
Total Sample Weight (Milligrams)	5.08	2.46	4.44	3.99
Grains/DSCF	0.00150	0.000735	0.00135	0.00119
Pounds/Hour	0.4063	0.1961	0.3592	0.3199
Pounds/Ton	0.0193	0.00934	0.01735	0.01531
AMMONIUM NITRATE PARTICULATE [c]				
Total Sample Weight (Milligrams)	415.4	407.6	472.1	431.7
Grains/DSCF	0.1225	0.1218	0.1436	0.1292
Pounds/Hour	33.22	32.50	38.19	34.62
Pounds/Ton				
TOTAL PARTICULATE: INSOLUBLE AND AMMONIUM NITRATE				
Total Sample Weight (Milligrams)	420.48	410.06	476.54	435.69
Grains/DSCF	0.1240	0.1226	0.1450	0.1304
Pounds/Hour	33.63	32.69	38.55	34.94
Pounds/Ton				
PERCENT PARTICULATE CATCH *	1.21	0.60	0.93	0.92

[a] Dry standard cubic feet @ 68^{o}F, 29.92 inches Hg.
[b] Dry standard cubic feet per minute.
[c] Specific Ion Electrode analysis method. This method measures nitrate (NO_3^-); ammonium nitrate (mg) = nitrate (mg) X 80/62.
* (Insoluble particulate/Total particulate) X 100.

TABLE 2-10

SUMMARY OF AMMONIUM NITRATE AND INSOLUBLE PARTICULATE MEASUREMENTS
ON GASES EXITING THE PRILL COOLER SCRUBBER
AT C F INDUSTRIES, INC.,
HARRISON, TENNESSEE

RUN NUMBER	RUN 1		RUN 2		RUN 3		AVERAGE	
DATE	05-10-79		05-11-79		05-11-79			
SCRUBBER OUTLET	EAST	WEST	EAST	WEST	EAST	WEST	EAST	WEST
VOLUME OF GAS SAMPLED (DSCF) [a]	62.70	111.60	64.08	110.50	63.10	107.40	63.29	109.83
PERCENT MOISTURE BY VOLUME	2.296	2.284	3.713	2.593	2.360	2.504	2.790	2.460
AVERAGE STACK TEMPERATURE (^{o}F)	114	122	110	119	115	122	113	121
STACK VOLUMETRIC FLOWRATE (DSCFM) [b]	18000	16410	17700	15960	17550	15590	17750	15990
PERCENT ISOKINETIC	96.8	98.8	100.7	100.7	103.3	100.1	100.3	99.9
PRODUCTION RATE (TONS/HOUR)	21.0	21.0	21.0	21.0	20.7	20.7	20.9	20.9
INSOLUBLE PARTICULATE								
Total Sample Weight (Milligrams)	1.03	6.80	0.39	6.23	5.94	14.16	2.45	9.07
Grains/DSCF	0.000254	0.000940	0.000094	0.000870	0.001453	0.002035	0.000598	0.001274
Pounds/Hour	0.03911	0.13226	0.01426	0.11902	0.21857	0.27193	0.09098	0.17461
Pounds/Ton	0.00186	0.00630	0.00068	0.00567	0.01056	0.01314	0.00435	0.00835
AMMONIUM NITRATE PARTICULATE [c]								
Total Sample Weight (Milligrams)	54.95	39.99	97.01	52.89	30.44	41.28	60.80	44.72
Grains/DSCF	0.01352	0.00553	0.02336	0.00739	0.00744	0.00593	0.01483	0.00628
Pounds/Hour	2.087	0.7778	3.544	1.011	1.119	0.7924	2.256	0.8607
Pounds/Ton	0.09938	0.03704	0.16876	0.04814	0.05406	0.03828	0.10794	0.04118
TOTAL PARTICULATE: INSOLUBLE AND AMMONIUM NITRATE								
Total Sample Weight (Milligrams)	55.98	46.79	97.40	59.12	36.38	55.44	63.25	53.79
Grains/DSCF	0.01378	0.00647	0.02346	0.00826	0.00890	0.00797	0.01542	0.00756
Pounds/Hour	2.126	0.9101	3.559	1.130	1.339	1.065	2.346	1.036
Pounds/Ton	0.1012	0.0433	0.1695	0.0538	0.0647	0.0515	0.1122	0.0496
PERCENT PARTICULATE CATCH *	1.84	14.53	0.40	10.54	16.33	25.54	3.87	16.86

[a] Dry standard cubic feet @ 68^{o}F, 29.92 inches Hg

[b] Dry standard cubic feet per minute.

[c] Specific Ion Electrode Analysis method. This method measures nitrate (NO_3-); ammonium nitrate (mg) = nitrate (mg) X 80/62.

* (Insoluble particulate/Total Particulate) X 100.

In Table 2-10 the west outlet insoluble particulate concentrations are about twice those from the cast. This difference is magnified in the calculated percent particulate catch by the fact that the east outlet ammonium nitrate concentration is more than twice that of the west outlet. The reasons for these differences between the east and west outlets are not evident.

The ammonia measurement data for the inlet and two outlet gas stream samples are shown in Tables 2-11, 2-12 and 2-13. The average ammonia removal efficiency was 79.0 percent.

2.3 Neutralizer Scrubbers

Ammonium nitrate and insoluble particulate data for the neutralizer No. 1 scrubber inlet and outlet gas stream samples are shown in Tables 2-14, 2-15 and 2-16. The average total particulate removal efficiency was 93.7 percent. Two special tests were performed on the neutralizer No. 2 outlet only: simultaneous test runs at 200% isokinetic and 50% isokinetic were run at single points in order to determine if deviations from strict isokinetic sampling techniques in a high water content gas stream (such as these neutralizer scrubber outlets) affect the sampling results. The ammonium nitrate and insoluble particulate data for these special tests are shown in Table 2-17. Because of the scatter of the data, no definite conclusions on the effects of the anisokinetic sampling can be drawn.

The leak check of the sampling train after the first inlet run revealed a significant leak; as a result the Run 1 inlet sample volume and flowrate are not included in the averages (Tables 2-14 and 2-15). The second and third runs leak-checked satisfactorily, but the calculated percent isokinetics are high for these two runs. These high isokinetics may be due to a slight error in the calculated in-stack calibration factor.

TABLE 2-11a (English)

SUMMARY OF AMMONIA AND CALCULATED AMMONIUM NITRATE MEASUREMENTS
ON GASES ENTERING AND EXITING THE PRILL COOLER SCRUBBER
AT C F INDUSTRIES, INC.,
HARRISON, TENNESSEE

RUN NUMBER	Run 1		Run 2		Run 3		Average	
DATE	05-10-79		05-10-79		05-10-79			
LOCATION	Inlet	Combined Outlet	Inlet	Combined Outlet	Inlet	Combined Outlet	Inlet	Combined Outlet
VOLUME OF GAS SAMPLED (DSCF)[a]	52.35	174.30	51.63	174.58	50.72	170.50	51.57	173.12
PERCENT MOISTURE BY VOLUME*	1.879	2.290	1.447	3.182	0.755	2.428	1.360	2.634
AVERAGE STACK TEMPERATURE (^{O}F)*	143	118	144	114	145	118	144	117
STACK VOLUMETRIC FLOWRATE (DSCFM)[b]	31650	34410	31120	33660	31020	33140	31260	33740
PERCENT ISOKINETIC	99.3	97.8	99.6	100.7	98.2	101.7	99.0	100.1
PRODUCTION RATE (TONS/HOUR)	21.0	21.0	21.0	21.0	20.7	20.7	20.9	20.9
AMMONIA[c]								
Total Sample Weight (Milligrams)	86.2	42.0	98.7	76.5	116.4	72.4	100.4	63.6
Grains/DSCF*	0.02541	0.00383	0.02950	0.00730	0.03479	0.00659	0.03004	0.00590
Pounds/Hour	6.894	1.130	7.869	1.947	9.280	1.872	8.050	1.706
Pounds/Ton	0.3283	0.0538	0.3747	0.09270	0.4483	0.0904	0.3889	0.0816
Collection Efficiency (Percent)	83.6		75.3		79.8		79.0	
AMMONIUM NITRATE CALCULATED FROM AMMONIA[d]								
Total Sample Weight (Milligrams)	405.6	197.6	464.5	360.0	547.8	340.7	472.5	299.3
Grains/DSCF*	0.1196	0.01802	0.1388	0.0344	0.1637	0.03101	0.1414	0.02776
Pounds/Hour	32.44	5.315	37.03	9.176	43.68	8.809	37.89	8.028
Pounds/Ton	1.545	0.253	1.764	0.437	2.110	0.426	1.830	0.3841
Collection Efficiency (Percent)	83.6		75.3		79.8		79.0	

a Dry standard cubic feet @ 68^{O}F and 29.92 inches Hg.

b Dry standard cubic feet per minute.

c Specific Ion Electrode Analysis method.

d Ammonium nitrate (mg) = Ammonia (mg) x 80/17.

* Combined outlet values are weighted averages (weighted by flowrate). Separate outlet values are shown in Table 2-13.

TABLE 2-11b (Metric)

SUMMARY OF AMMONIA AND CALCULATED AMMONIUM NITRATE MEASUREMENTS ON GASES ENTERING AND EXITING THE PRILL COOLER SCRUBBER AT C F INDUSTRIES, INC., HARRISON, TENNESSEE

RUN NUMBER	Run 1		Run 2		Run 3		Average	
DATE	05-10-79		05-10-79		05-10-79			
LOCATION	Inlet	Combined Outlets	Inlet	Combined Outlets	Inlet	Combined Outlets	Inlet	Combined Outlets
VOLUME OF GAS SAMPLED (DN m^3)[a]	1.483	4.936	1.462	4.944	1.436	4.829	1.460	4.903
PERCENT MOISTURE BY VOLUME*	1.879	2.290	1.447	3.182	0.755	2.428	1.360	2.634
AVERAGE STACK TEMPERATURE (^oC)*	62	48	63	46	63	48	63	48
STACK VOLUMETRIC FLOWRATE (DN m^3/min)[b]	896	974	881	953	878	939	885	956
PERCENT ISOKINETIC	99.3	97.8	99.6	100.7	98.2	101.7	99.0	100.1
PRODUCTION RATE (Mg/Hour)	19.1	19.1	19.1	19.1	18.8	18.8	19.0	19.0
AMMONIA[c]								
Total Sample Weight (Milligrams)	86.2	42.0	98.7	76.5	116.4	72.4	100.4	63.6
Grams/DN m^3*	0.05814	0.00876	0.06750	0.01670	0.07960	0.01508	0.06873	0.01350
Kg/Hour	3.127	0.513	3.569	0.883	4.209	0.849	3.651	0.774
Kg/Mg	0.1642	0.0269	0.1874	0.0464	0.2242	0.0452	0.1945	0.0408
Collection Efficiency (Percent)	83.6		75.3		79.8		79.0	
AMMONIUM NITRATE CALCULATED FROM AMMONIA[d]								
Total Sample Weight (Milligrams)	405.6	197.6	464.5	360.0	547.8	340.7	472.5	299.3
Grams/DN m^3*	0.2737	0.04123	0.3176	0.0787	0.3746	0.07096	0.3235	0.06352
Kg/Hour	14.71	2.411	16.80	4.162	19.81	3.996	17.19	3.642
Kg/Mg	0.773	0.127	0.882	0.219	1.055	0.213	0.915	0.1921
Collection Efficiency (Percent)	83.6		75.3		79.8		79.0	

a Dry normal cubic meters @ 20°C, 760 mm Hg.

b Dry normal cubic meters per minute.

c Specific Ion Electrode Analysis method.

d Ammonium nitrate (mg) = Ammonia (mg) x 80/17.

* Combined outlet values are weighted averages (weighted by flowrate). Separate outlet values are shown in Table 2-13.

TABLE 2-12

SUMMARY OF AMMONIA, CALCULATED AMMONIUM NITRATE AND CALCULATED EXCESS AMMONIA MEASUREMENTS ON GASES ENTERING THE PRILL COOLER SCRUBBER AT C F INDUSTRIES, INC., HARRISON, TENNESSEE

RUN NUMBER	Run 1	Run 2	Run 3	Average
DATE	05-10-79	05-11-79	05-11-79	
VOLUME OF GAS SAMPLED (DSCF)[a]	52.35	51.63	50.72	51.57
STACK VOLUMETRIC FLOWRATE (DSCFM)[b]	31650	31120	31020	31260
PRODUCTION RATE (TONS/HOUR)	21.0	21.0	20.7	20.9
TOTAL AMMONIA[c]				
Total Sample Weight (Milligrams)	86.2	98.7	116.4	100.4
Grains/DSCF	0.02541	0.02950	0.03479	0.03004
Pounds/Hour	6.894	7.869	9.280	8.050
Pounds/Ton	0.3283	0.3747	0.4483	0.3889
AMMONIUM NITRATE CALCULATED FROM AMMONIA[d]				
Total Sample Weight (Milligrams)	405.6	464.5	547.8	472.5
Grains/DSCF	0.1196	0.1388	0.1637	0.1414
Pounds/Hour	32.44	37.03	43.68	37.89
Pounds/Ton	1.545	1.764	2.110	1.830
EXCESS AMMONIA[e]				
Total Sample Weight (Milligrams)	-2.08	12.09	16.09	14.09[f]
Grains/DSCF		0.003613	0.004900	0.004216[f]
Pounds/Hour		0.9639	1.3017	1.1297[f]
Pounds/Ton		0.0459	0.0629	0.0541[f]

a Dry standard cubic feet @ 68°F, 29.92 inches Hg.

b Dry standard cubic feet per minute.

c Specific Ion Electrode Analysis method.

d Ammonium nitrate (mg) = Ammonia (mg) X 80/17.

e Excess Ammonia = ((Ammonium nitrate calculated from ammonia) - (Ammonium nitrate measured directly, from Table 2-9)) X 17/80.

f Averages include only Runs 2 and 3.

TABLE 2-13a

SUMMARY OF AMMONIA, CALCULATED AMMONIUM NITRATE AND CALCULATED EXCESS AMMONIA MEASUREMENTS ON GASES FROM THE PRILL COOLER SCRUBBER EAST OUTLET AT C F INDUSTRIES, INC., HARRISON, TENNESSEE

RUN NUMBER	RUN 1		RUN 2		RUN 3		AVERAGE	
DATE	05-10-79		05-11-79		05-11-79			
VOLUME OF GAS SAMPLED (DSCF) [a]	62.70		64.08		63.10		63.29	
STACK VOLUMETRIC FLOW RATE (DSCFM) [b]	18000		17700		17550		17750	
PRODUCTION RATE (TONS/HOUR)	21.0		21.0		20.7		20.9	
TOTAL AMMONIA	SIE [c]	NESSLER [d]	SIE	NESSLER	SIE	NESSLER	SIE	NESSLER
Total Sample Weight (Milligrams)	16.9	13.9	36.9	34.1	27.4	22.0	27.0	23.3
Grains/DSCF	0.004159	0.003421	0.008887	0.008212	0.006701	0.005380	0.006584	0.005681
Pounds/Hour	0.6417	0.5278	1.348	1.246	1.008	0.8093	1.002	0.8643
Pounds/Ton	0.03056	0.02513	0.06419	0.05933	0.04870	0.03910	0.04794	0.04135
AMMONIUM NITRATE CALCULATED FROM AMMONIA [e]								
Total Sample Weight (Milligrams)	79.5	65.4	173.6	160.5	128.9	103.5	127.1	109.6
Grains/DSCF	0.01957	0.01610	0.04181	0.03865	0.03152	0.02531	0.03100	0.02672
Pounds/Hour	3.019	2.484	6.342	5.864	4.742	3.808	4.715	4.066
Pounds/Ton	0.1438	0.1183	0.3020	0.2792	0.2291	0.1839	0.2256	0.1945
EXCESS AMMONIA [f]								
Total Sample Weight (Milligrams)	5.22	2.22	16.28	13.49	20.92	15.52	14.09	10.37
Grains/DSCF	0.00129	0.00055	0.00392	0.00325	0.00512	0.00380	0.00344	0.00253
Pounds/Hour	0.1990	0.0849	0.5947	0.4931	0.7702	0.5716	0.5234	0.3849
Pounds/Ton	0.00948	0.00404	0.02832	0.02348	0.03721	0.02761	0.02504	0.01842

[a] Dry standard cubic feet @ 68°F, 29.92 inches Hg.

[b] Dry standard cubic feet per minute.

[c] Specific Ion Electrode Analysis method.

[d] Nessler (with preliminary distillation) analysis method.

[e] Ammonium nitrate (mg) = Ammonia (mg) X 80/17.

[f] Excess Ammonia = ((Ammonium nitrate calculated from ammonia) - (Ammonium nitrate measured directly, from Table 2-10)) X 17/80.

TABLE 2-13b

SUMMARY OF AMMONIA, CALCULATED AMMONIUM NITRATE AND CALCULATED EXCESS AMMONIA MEASUREMENTS ON GASES FROM THE PRILL COOLER SCRUBBER WEST OUTLET AT C F INDUSTRIES, INC., HARRISON, TENNESSEE

RUN NUMBER	Run 1		Run 2		Run 3		Average	
DATE	05-10-79		05-11-79		05-11-79			
VOLUME OF GAS SAMPLED (DSCF)[a]	111.60		110.50		107.40		109.83	
STACK VOLUMETRIC FLOWRATE (DSCFM)[b]	16410		15960		15590		15990	
PRODUCTION RATE (TONS/HOUR)	21.0		21.0		20.7		20.9	
TOTAL AMMONIA	SIE[c]	NESSLER[d]	SIE	NESSLER	SIE	NESSLER	SIE	NESSLER
Total Sample Weight (Milligrams)	25.1	23.4	39.6	35.6	45.0	38.7	36.6	32.6
Grains/DSCF	0.003471	0.003236	0.005530	0.004972	0.006466	0.005561	0.005143	0.004581
Pounds/Hour	0.4882	0.4552	0.7565	0.6802	0.8640	0.7431	0.7049	0.6279
Pounds/Ton	0.02325	0.02168	0.03602	0.03239	0.04174	0.03590	0.03373	0.03004
AMMONIUM NITRATE CALCULATED FROM AMMONIA[e]								
Total Sample Weight (Milligrams)	118.1	110.1	186.4	167.5	211.8	182.1	172.2	153.4
Grains/DSCF	0.01633	0.01522	0.02603	0.02339	0.03043	0.02617	0.02420	0.02155
Pounds/Hour	2.297	2.141	3.561	3.200	4.066	3.497	3.317	2.954
Pounds/Ton	0.10938	0.10195	0.16957	0.15238	0.19643	0.16894	0.15871	0.14134
EXCESS AMMONIA[f]								
Total Sample Weight (Milligrams)	16.6	14.9	28.4	24.4	36.2	29.9	27.1	23.1
Grains/DSCF	0.00230	0.00206	0.00397	0.00341	0.00520	0.00430	0.00381	0.00325
Pounds/Hour	0.3235	0.2898	0.5431	0.4665	0.6949	0.5746	0.5222	0.4454
Pounds/Ton	0.01540	0.01380	0.02586	0.02221	0.03357	0.02776	0.02499	0.02131

a Dry standard cubic feet @ 68°F, 29.92 inches Hg.

b Dry standard cubic feet per minute.

c Specific Ion Electrode Analysis method.

d Nessler (with preliminary distillation) analysis method.

e Ammonium nitrate (mg) = ammonia (mg) x 80/17

f Excess ammonia = [(Ammonium nitrate calculated from ammonia) - (ammonium nitrate measured directly, from Table 2-10)] x 17/80.

TABLE 2-14a (English)

SUMMARY OF AMMONIUM NITRATE AND INSOLUBLE PARTICULATE MEASUREMENTS ON GASES ENTERING AND EXITING NEUTRALIZER NO. 1 SCRUBBER AT C F INDUSTRIES, INC., HARRISON, TENNESSEE

RUN NUMBER	Run 1		Run 2		Run 3		Average*	
DATE	06-19-79		06-20-79		06-20-79			
LOCATION	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet
VOLUME OF GAS SAMPLED (DSCF)[a]	0.329	6.582	4.568	5.484	4.200	5.814	4.384[d]	5.960
PERCENT MOISTURE BY VOLUME	99.53	94.23	94.43	95.01	95.24	94.85	94.84[d]	94.70
AVERAGE STACK TEMPERATURE (^{o}F)	269	213	275	212	270	210	271	212
STACK VOLUMETRIC FLOWRATE (DSCFM)[b]	27.85	378.3	315.6	302.1	260.7	326.3	288.2[d]	335.6
PERCENT ISOKINETIC	92.74	110.1	113.7	114.9	126.6	112.8	120.2[d]	112.6
PRODUCTION RATE (TONS/HOUR)	11.3	11.3	11.5	11.5	11.4	11.4	11.4	11.4
INSOLUBLE PARTICULATE								
Total Sample Weight (Milligrams)	129.51	75.88	69.49	97.75	53.03	99.39	84.01	91.01
Grains/DSCF	6.075	0.1779	0.2348	0.2751	0.1948	0.2638	0.2957	0.2357
Pounds/Hour	1.450	0.5987	0.6352	0.7356	0.4353	0.7615	0.7305	0.7012
Pounds/Ton	0.12832	0.05299	0.05523	0.06397	0.03818	0.06680	0.06408	0.06151
Collection Efficiency (Percent)	58.7		<0		<0		4.0	
AMMONIUM NITRATE PARTICULATE[c]								
Total Sample Weight (Milligrams)	6344	474	6890	387	7474	353	6903	405
Grains/DSCF	297.6	1.111	23.28	1.089	27.46	0.9370	24.30	1.049
Pounds/Hour	71.04	3.739	62.98	2.912	61.36	2.704	60.03	3.121
Pounds/Ton	6.2867	0.33088	5.4765	0.25326	5.3825	0.23723	5.2658	0.27378
Collection Efficiency (Percent)	94.7		95.4		95.6		94.8	
TOTAL PARTICULATE: INSOLUBLE AND AMMONIUM NITRATE								
Total Sample Weight (Milligrams)	6474	549.9	6960	484.8	7527	452.4	6987	496.0
Grains/DSCF	303.7	1.289	23.51	1.364	27.66	1.201	24.59	1.284
Pounds/Hour	72.50	4.338	63.60	3.647	61.81	3.467	60.74	3.820
Pounds/Ton	6.4159	0.38388	5.5304	0.31715	5.4219	0.30416	5.3281	0.33507
Collection Efficiency (Percent)	94.0		94.3		94.4		93.7	

a Dry standard cubic feet @ 68^{o}F, 29.92 inches Hg.

b Dry standard cubic feet per minute.

c Specific Ion Electrode Analysis method.

d These averages include only Runs 2 and 3 due to high sampling train leak rate during Run 1.

* Averages include all three runs except for parameters identified by d.

Grains/DSCF, pounds/hour and pounds/ton are calculated from average Total Sample Weights.

TABLE 2-14b (Metric)

SUMMARY OF AMMONIUM NITRATE AND INSOLUBLE PARTICULATE MEASUREMENTS ON GASES ENTERING AND EXITING NEUTRALIZER NO. 1 SCRUBBER AT C F INDUSTRIES, INC., HARRISON, TENNESSEE

RUN NUMBER	Run 1		Run 2		Run 3		Average*	
DATE	06-19-79		06-20-79		06-20-79			
LOCATION	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet
VOLUME OF GAS SAMPLED (DN m^3)[a]	0.0093	0.1864	0.1294	0.1553	0.1189	0.1647	0.1242[d]	0.1688
PERCENT MOISTURE BY VOLUME	99.53	94.23	94.43	95.01	95.24	94.85	94.84[d]	94.70
AVERAGE STACK TEMPERATURE (^oC)	132	101	135	100	132	99	133	100
STACK VOLUMETRIC FLOWRATE (DN m^3/min)[b]	0.7887	10.71	8.938	8.555	7.383	9.241	8.162[d]	9.502
PERCENT ISOKINETIC	92.7	110.1	113.7	114.9	126.6	112.8	120.2[d]	112.6
PRODUCTION RATE (Mg/Hour)	10.2	10.2	10.5	10.5	10.4	10.4	10.4	10.4
INSOLUBLE PARTICULATES								
Total Sample Weight (Milligrams)	129.51	75.88	69.49	97.75	53.03	99.39	84.01	91.01
Grams/DN m^3	13.90	0.4071	0.5372	0.6295	0.4457	0.6036	0.6766	0.5393
Kg/Hour	0.6577	0.2716	0.2881	0.3337	0.1975	0.3454	0.3314	0.3182
Kg/Mg	0.06416	0.02650	0.02762	0.03199	0.01909	0.03340	0.03204	0.03076
Collection Efficiency (Percent)	58.7		<0		<0		4.0	
AMMONIUM NITRATE PARTICULATE[c]								
Total Sample Weight (Milligrams)	6344	474	6890	387	7474	353	6903	405
Grams/DN m^3	681.0	2.542	53.27	2.492	62.83	2.144	55.60	2.400
Kg/Hour	32.22	1.696	28.57	1.321	27.83	1.226	27.23	1.416
Kg/Mg	3.1434	0.16542	2.7383	0.12663	2.6913	0.11862	2.6329	0.13693
Collection Efficiency (Percent)	94.7		95.4		95.6		94.8	
TOTAL PARTICULATE: INSOLUBLE AND AMMONIUM NITRATE								
Total Sample Weight (Milligrams)	6474	549.9	6960	484.8	7527	452.4	6987	496.0
Grams/DN m^3	694.9	2.949	53.79	3.121	63.29	2.748	56.26	2.938
Kg/Hour	32.89	1.967	28.85	1.654	28.04	1.573	27.55	1.733
Kg/Mg	3.2080	0.19193	2.7652	0.15859	2.7110	0.15208	2.6641	0.16758
Collection Efficiency (Percent)	94.0		94.3		94.4		93.7	

a Dry normal cubic meters @ 20°C, 760 mm Hg.

b Dry normal cubic meters per minute.

c Specific Ion Electrode Analysis method.

d These averages include only Runs 2 and 3 due to high sampling train leak rate during Run 1.

* Averages include all three runs except for parameters identified by d.

Grains/DSCF, pounds/hour and pounds/ton are calculated from average Total Sample Weights.

TABLE 2-15

SUMMARY OF AMMONIUM NITRATE AND INSOLUBLE PARTICULATE MEASUREMENTS
ON GASES ENTERING NEUTRALIZER #1 SCRUBBER
AT C F INDUSTRIES, INC.,
HARRISON, TENNESSEE

RUN NUMBER	RUN 1	RUN 2	RUN 3	AVERAGE**
DATE	06-19-79	06-20-79	06-20-79	
VOLUME OF GAS SAMPLED (DSCF) [a]	0.329	4.568	4.200	4.384 [d]
PERCENT MOISTURE BY VOLUME	99.53	94.43	95.24	94.84 [d]
AVERAGE STACK TEMPERATURE (^{o}F)	269	275	270	271
STACK VOLUMETRIC FLOW RATE (DSCFM)[b]	27.85	315.6	260.7	288.2 [d]
PERCENT ISOKINETIC	92.74	113.7	126.6	120.2 [d]
PRODUCTION RATE (TONS/HOUR)	11.3	11.5	11.4	11.4
INSOLUBLE PARTICULATE				
Total Sample Weight (Milligrams)	129.51	69.49	53.03	84.01
Grains/DSCF	6.075	0.2348	0.1948	0.2957
Pounds/Hour	1.450	0.6352	0.4353	0.7305
Pounds/Ton	0.12832	0.05523	0.03818	0.06408
AMMONIUM NITRATE PARTICULATE [c]				
Total Sample Weight (Milligrams)	6344	6890	7474	6903
Grains/DSCF	297.6	23.28	27.46	24.30
Pounds/Hour	71.04	62.98	61.36	60.03
Pounds/Ton	6.2867	5.4765	5.3825	5.2658
TOTAL PARTICULATE: INSOLUBLE AND AMMONIUM NITRATE				
Total Sample Weight (Milligrams)	6474	6960	7527	6987
Grains/DSCF	303.7	23.51	27.66	24.59
Pounds/Hour	72.50	63.60	61.81	60.74
Pounds/Ton	6.4159	5.5304	5.4219	5.3281
PERCENT PARTICULATE CATCH *	2.0	1.0	0.7	1.2

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

[b] Dry standard cubic feet per minute.

[c] Specific Ion Electrode Analysis method. This method measures nitrate (NO_3-); ammonium nitrate (mg) = nitrate (mg) X 80/62.

[d] These averages include only Runs 2 and 3 due to a high sampling train leak rate during Run 1.

* (Insoluble particulate/Total particulate) X 100.

** Averages include all three runs except parameters identified by d.

TABLE 2-16

SUMMARY OF AMMONIUM NITRATE AND INSOLUBLE PARTICULATE MEASUREMENTS
ON GASES EXITING NEUTRALIZER #1 SCRUBBER
AT C F INDUSTRIES, INC.,
HARRISON, TENNESSEE

	RUN 1	RUN 2	RUN 3	AVERAGE
RUN NUMBER				
DATE	06-19-79	06-20-79	06-20-79	
VOLUME OF GAS SAMPLED (DSCF) [a]	6,582	5,484	5,814	5,960
PERCENT MOISTURE BY VOLUME	94.23	95.01	94.85	94.70
AVERAGE STACK TEMPERATURE (^{o}F)	213	212	210	212
STACK VOLUMETRIC FLOW RATE (DSCFM) [b]	378.3	302.1	326.3	335.6
PERCENT ISOKINETIC	110.1	114.9	112.8	112.6
PRODUCTION RATE (TONS/HOUR)	11.3	11.5	11.4	11.4
INSOLUBLE PARTICULATE				
Total Sample Weight (Milligrams)	75.88	97.75	99.39	91.01
Grains/DSCF	0.1779	0.2751	0.2638	0.2357
Pounds/Hour	0.5987	0.7356	0.7615	0.7012
Pounds/Ton	0.05299	0.06397	0.06680	0.06151
AMMONIUM NITRATE PARTICULATE [c]				
Total Sample Weight (Milligrams)	474	387	353	405
Grains/DSCF	1.111	1.089	0.9370	1.049
Pounds/Hour	3.739	2.912	2.704	3.121
Pounds/Ton	0.33088	0.25326	0.23723	0.27378
TOTAL PARTICULATE: INSOLUBLE AND AMMONIUM NITRATE				
Total Sample Weight (Milligrams)	549.9	484.8	452.4	496.0
Grains/DSCF	1.289	1.364	1.201	1.284
Pounds/Hour	4.388	3.647	3.467	3.820
Pounds/Ton	0.38388	0.31715	0.30416	0.33507
PERCENT PARTICULATE CATCH *	13.8	20.2	22.0	18.3

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

[b] Dry standard cubic feet per minute.

[c] Specific Ion Electrode Analysis method. This method measures nitrate (NO_3-); ammonium nitrate (mg) = nitrate (mg) X 80/62.

* (Insoluble particulate/Total Particulate) X 100.

TABLE 2-17

SUMMARY OF AMMONIUM NITRATE AND INSOLUBLE PARTICULATE MEASUREMENTS ON GASES EXITING NEUTRALIZER NO. 2 SCRUBBER AT C F INDUSTRIES, INC., HARRISON, TENNESSEE

RUN NUMBER	Run 4		Run 5		Run 6		Average	
DATE	06-21-79		06-21-79		06-21-79			
APPROXIMATE ISOKINETIC	200%	50%	200%	50%	200%	50%	200%	50%
VOLUME OF GAS SAMPLED (DSCF)[a]	3.493	2.466	3.405	2.642	2.792	2.508	3.230	2.539
PERCENT MOISTURE BY VOLUME	94.01	93.90	94.19	94.12	95.09	94.50	94.43	94.17
AVERAGE STACK TEMPERATURE (^{O}F)	209	212	211	212	210	211	210	212
PERCENT ISOKINETIC	206.1	51.0	212.9	55.7	206.8	48.4	208.6	51.7
INSOLUBLE PARTICULATE								
Total Sample Weight (Milligrams)	27.78	25.71	66.60	40.06	27.60	28.94	40.66	31.57
Grains/DSCF	0.1227	0.1609	0.3018	0.2340	0.1526	0.1781	0.1943	0.1919
Difference (Percent)*	-31.1		22.5		-16.7		1.2	
AMMONIUM NITRATE PARTICULATE								
Total Sample Weight (Milligrams)	132.0	98.9	158.0	116.5	194.0	130.0	161.0	115.1
Grains/DSCF	0.5832	0.6189	0.7161	0.6805	1.072	0.7997	0.7692	0.6996
Difference (Percent)*	-6.1		-5.0		25.4		9.0	
TOTAL PARTICULATE: INSOLUBLE AND AMMONIUM NITRATE								
Total Sample Weight (Milligrams)	159.8	124.6	224.6	156.6	221.6	158.9	202.0	146.7
Grains/DSCF	0.7060	0.7797	1.018	0.9147	1.225	0.9777	0.9651	0.8916
Difference (Percent)*	-10.4		10.1		20.2		7.6	

a Dry standard cubic feet @ 68°F, 29.92 inches Hg.

b Specific Ion Electrode Analysis method. This method measures nitrate (NO_3-); ammonium nitrate (mg) = nitrate (mg) x 80/62.

* Relative difference between 200% and 50% grain loadings; defined here as 100 X ((200% gr/DSCF) - (50% gr/DSCF))/(200% gr/DSCF).

Because of the high ammonia concentration in the neutralizer samples, the ammonium nitrate values shown in Tables 2-14, 2-15, and 2-16 may be somewhat higher than what actually exists. The interference effects of ammonia on the ammonium nitrate analyses are discussed in Section 5.0.

The ammonia measurement data from the neutralizer No. 1 inlet and outlet gas stream samples are shown in Tables 2-18 (inlet and outlet) 2-19 (inlet) and 2-20 (outlet). The average ammonia removal efficiency was calculated to be less than zero, indicating more ammonia leaving the scrubber than entering. The implication is that ammonia is being stripped from the scrubber water. However, since only the scrubber inlet water was sampled and analyzed, the reason for this negative ammonia removal efficiency remains unclear.

The ammonia measurement data from the 200% and 50% isokinetic sampling at neutralizer No. 2 outlet are shown in Tables 2-21 (200% data) and 2-22 (50% data). As with the particulate data in Table 2-17, no definite conclusions on the effects of the anisokinetic sampling can be drawn.

The carbon dioxide content of the Neutralizer No. 1 and No. 2 samples was evaluated by CFI using the Van Slyke analysis method. The results of these analyses (corrected to 70°F and 29.92 inches Hg) are as follows:

Location	Run	CO_2 Concentrations (SCF/gallon)	
Neutralizer No. 1 Scrubber		Inlet	Outlet
	1	1.079	1.220
	2	1.284	1.592
	3	1.926	2.465
Neutralizer No. 2 Scrubber Outlet		200%	50%
	1	0.411	0.462
	2	0.770	0.642
	3	0.899	0.899

TABLE 2-18a (English)

SUMMARY OF AMMONIA AND CALCULATED AMMONIUM NITRATE MEASUREMENTS ON GASES ENTERING AND EXITING NEUTRALIZER NO. 1 SCRUBBER AT C F INDUSTRIES, INC., HARRISON, TENNESSEE

RUN NUMBER	Run 1		Run 2		Run 3		Average*	
DATE	06-19-79		06-20-79		06-20-79			
LOCATION	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet
VOLUME OF GAS SAMPLED (DSCF)[a]	0.329	6.582	4.568	5.484	4.200	5.814	4.384[e]	5.960
PERCENT MOISTURE BY VOLUME	99.53	94.23	94.43	95.01	95.24	94.85	94.84[e]	94.70
AVERAGE STACK TEMPERATURE (^{o}F)	269	213	275	212	270	210	271	212
STACK VOLUMETRIC FLOWRATE (DSCFM)[b]	27.85	378.3	315.6	302.1	260.7	326.3	288.2[e]	335.6
PERCENT ISOKINETIC	92.7	110.1	113.7	114.9	126.6	112.8	120.2[e]	112.6
PRODUCTION RATE (TONS/HOUR)	11.3	11.3	11.5	11.5	11.4	11.4	11.4	11.4
AMMONIA[c]								
Total Sample Weight (Milligrams)	27906	41152	52979	64039	64530	97634	48472	67608
Grains/DSCF	1309	96.48	179.0	180.2	237.1	259.1	170.6	175.1
Pounds/Hour	312.5	324.7	484.2	481.9	529.8	747.9	421.4	520.9
Pounds/Ton	27.65	28.73	42.10	41.90	46.47	65.61	36.96	45.69
Collection Efficiency (Percent)	<0		0.5		<0		<0	
AMMONIUM NITRATE CALCULATED FROM AMMONIA[d]								
Total Sample Weight (Milligrams)	131322	193656	249313	301360	303671	459454	228104	318155
Grains/DSCF	6160	454.0	842.3	848.0	1116	1220	802.9	823.8
Pounds/Hour	1470	1528	2279	2267	2494	3522	1983	2451
Pounds/Ton	130.1	135.2	198.2	197.1	218.8	308.9	173.9	215.0
Collection Efficiency (Percent)	<0		0.6		<0		<0	

a Dry standard cubic feet @ 68^{o}F, 29.92 inches Hg.

b Dry standard cubic feet per minute.

c Specific Ion Electrode Analysis method.

d Ammonium nitrate (mg) = ammonia (mg) x 80/17.

e These averages include Runs 2 and 3 only because of high sampling train leak rate during Run 1.

* Averages include all three runs except for parameters identified by e.

Grains/DSCF, Pounds/Hour and pounds/ton are calculated from average Total Sample Weights.

TABLE 2-18b (Metric)

SUMMARY OF AMMONIA AND CALCULATED AMMONIUM NITRATE MEASUREMENTS
ON GASES ENTERING AND EXITING NEUTRALIZER NO. 1 SCRUBBER
AT C F INDUSTRIES, INC.,
HARRISON, TENNESSEE

RUN NUMBER	RUN 1		RUN 2		RUN 3		AVERAGE *	
DATE	06-19-79		06-20-79		06-20-79			
LOCATION	INLET	OUTLET	INLET	OUTLET	INLET	OUTLET	INLET	OUTLET
VOLUME OF GAS SAMPLED (DNm^3)[a]	.0093	0.1864	0.1294	0.1553	0.1189	0.1647	0.1242 [e]	0.1688
PERCENT MOISTURE BY VOLUME	99.53	94.23	94.43	95.01	95.24	94.85	94.84 [e]	94.70
AVERAGE STACK TEMPERATURE (^oC)	132	101	135	100	132	99	133	100
STACK VOLUMETRIC FLOWRATE (DNm^3/min) [b]	0.7887	10.71	8.938	8.555	7.383	9.241	8.162 [e]	9.502
PERCENT ISOKINETIC	92.7	110.1	113.7	114.9	126.6	112.8	120.2 [e]	112.6
PRODUCTION RATE (Mg/Hour)	10.2	10.2	10.5	10.5	10.4	10.4	10.4	10.4
AMMONIA [c]								
Total Sample Weight (Milligrams)	27906	41152	52979	64039	64530	97634	48472	67608
Grams/DNm^3	2995	220.8	409.6	412.3	542.5	592.8	390.3	400.6
Kg/Hour	141.8	147.3	219.6	218.6	240.3	339.2	191.1	236.3
Kg/Mg	13.83	14.4	21.05	20.96	23.24	32.80	18.48	22.86
COLLECTION EFFICIENCY (Percent)	<0		0.5		<0		<0	
AMMONIUM NITRATE CALCULATED FROM AMMONIA [d]								
Total Sample Weight (Milligrams)	131322	193656	249313	301360	303671	459454	228104	318155
Grams/DNm^3	14095	1039	1927	1940	2554	2791	1837	1885
Kg/Hour	666.8	693.1	1034	1028	1131	1598	899.5	1112
Kg/Mg	65.05	67.59	99.10	98.58	109.4	154.5	86.95	107.5
COLLECTION EFFICIENCY (Percent)	<0		0.6		<0		<0	

[a] Dry normal cubic meters @ 20°C, 760 mm Hg.

[b] Dry normal cubic meters per minute.

[c] Specific Ion Electrode analysis method.

[d] Ammonium nitrate (mg) = Ammonia (mg) X 80/17.

[e] These averages include Runs 2 and 3 only because of high sampling train leak rate during Run 1.

* Averages include all three runs except for parameters identified by e.

Grains/DSCF, Pounds/Hour and pounds/ton are calculated from average Total Sample Weights.

TABLE 2-19

SUMMARY OF AMMONIA, CALCULATED AMMONIUM NITRATE AND CALCULATED EXCESS AMMONIA MEASUREMENTS ON GASES ENTERING THE NEUTRALIZER NO. 1 SCRUBBER AT C F INDUSTRIES, INC., HARRISON, TENNESSEE

RUN NUMBER	RUN 1		RUN 2		RUN 3		AVERAGE	
DATE	06-19-79		06-20-79		06-20-79			
VOLUME OF GAS SAMPLED (DSCF) [a]	0.329		4.568		4.200		4.384*	
STACK VOLUMETRIC FLOWRATE (DSCFM) [b]	27.85		315.6		260.7		288.2*	
AVERAGE STACK TEMPERATURE (^{o}F)	269		275		270		271	
PRODUCTION RATE (TONS/HOUR)	11.3		11.5		11.4		11.4	
AMMONIA	SIE [c]	NESSLER [d]	SIE	NESSLER	SIE	NESSLER	SIE	NESSLER
Total Sample Weight (Milligrams)	27906	24705	52979	46955	64530	59091	48472	43584
Grains/DSCF	1309	1159	179.0	158.6	237.1	217.1	170.6	511.9
Pounds/Hour	312.5	276.6	484.2	429.1	529.8	485.2	421.4	396.8
Pounds/Ton	27.65	24.48	42.10	37.31	46.47	42.56	36.96	34.81
AMMONIUM NITRATE CALCULATED FROM AMMONIA [e]								
Total Sample Weight (Milligrams)	131322	116259	249313	220965	303671	278075	228104	205100
Grains/DSCF	6160	5453	842.3	746.5	1116	1022	802.9	722.0
Pounds/Hour	1470	1302	2279	2019	2494	2283	1983	1783
Pounds/Ton	130.1	115.2	198.2	175.6	218.8	200.3	173.9	156.4
EXCESS AMMONIA [f]								
Total Sample Weight (Milligrams)	26558	23357	51515	45491	62942	57503	47005	42117
Grains/DSCF	1246	1096	174.0	153.7	231.3	211.3	165.5	148.3
Pounds/Hour	297.4	261.5	470.8	415.6	516.8	472.1	408.7	366.2
Pounds/Ton	26.32	23.14	40.94	153.7	45.33	41.41	35.85	32.13

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

[b] Dry standard cubic feet per minute.

[c] Specific Ion Electrode Analysis method.

[d] Nessler (with preliminary distillation) analysis method.

[e] Ammonium nitrate (mg) = ammonia (mg) X 80/17.

[f] Excess ammonia = {(Ammonium nitrate calculated from ammonia) - (Ammonium nitrate calculated directly, from Table 2-15)} X 17/80.

* Includes runs 2 and 3 only.

TABLE 2-20

SUMMARY OF AMMONIA, CALCULATED AMMONIUM NITRATE AND CALCULATED EXCESS AMMONIA MEASUREMENTS ON GASES EXITING NEUTRALIZER NO. 1 SCRUBBER AT C F INDUSTRIES, INC., HARRISON, TENNESSEE

RUN NUMBER	RUN 1		RUN 2		RUN 3		AVERAGE	
DATE	06-19-79		06-20-79		06-20-79			
VOLUME OF GAS SAMPLED (DSCF) [a]	6,582		5,484		5,814		5,960	
STACK VOLUMETRIC FLOWRATE (DSCFM) [b]	378.3		302.1		326.3		335.6	
AVERAGE STACK TEMPERATURE	213		212		210		212	
PRODUCTION RATE (TONS/HOUR)	11.3		11.5		11.4		11.4	
AMMONIA	SIE [c]	NESSLER [d]	SIE	NESSLER	SIE	NESSLER	SIE	NESSLER
Total Sample Weight (Milligrams)	41152	36742	64039	60790	97634	97072	67608	64868
Grains/DSCF	96.48	86.14	180.2	171.1	259.1	257.7	175.1	171.6
Pounds/Hour	324.7	289.9	481.9	457.4	747.9	743.8	520.9	497.1
Pounds/Ton	28.73	25.66	41.90	39.77	65.61	65.24	45.69	43.62
AMMONIUM NITRATE CALCULATED FROM AMMONIA [e]								
Total Sample Weight (Milligrams)	193656	172904	301360	286070	459454	456809	318155	305261
Grains/DSCF	454.0	405.4	848.0	805.0	1220	1213	823.8	810.3
Pounds/Hour	1528	1364	2267	2152	3522	3500	2451	2341
Pounds/Ton	135.2	120.7	197.1	187.2	308.9	307.0	215.0	205.4
EXCESS AMMONIA [f]								
Total Sample Weight (Milligrams)	41051	36641	63957	60708	97559	96997	67522	64782
Grains/DSCF	96.25	85.91	180.0	170.8	259.0	257.5	174.8	172.0
Pounds/Hour	323.9	289.1	489.1	456.8	747.6	743.3	529.0	496.9
Pounds/Ton	28.67	25.58	41.85	39.72	65.59	65.19	45.63	43.59

[a] Dry standard cubic feet @ 68°F, 29.92 inches Hg.

[b] Dry standard cubic feet per minute.

[c] Specific Ion Electrode analysis method.

[d] Nessler (with preliminary distillation) analysis method.

[e] Ammonium nitrate (mg) = ammonia (mg) X 80/17.

[f] Excess ammonia = ((Ammonium nitrate calculated from ammonia) - (Ammonium nitrate calculated directly, from Table 2-16)) X 17/80.

TABLE 2-21

SUMMARY OF AMMONIA, CALCULATED AMMONIUM NITRATE AND CALCULATED EXCESS AMMONIA MEASUREMENTS ON GASES SAMPLED AT 200% ISOKINETIC EXITING NEUTRALIZER NO. 2 SCRUBBER AT C F INDUSTRIES, INC., HARRISON, TENNESSEE

RUN NUMBER	Run 4		Run 5		Run 6		Average	
DATE	06-21-79		06-21-79		06-21-79			
VOLUME OF GAS SAMPLED (DSCF)[a]	3.493		3.405		2.792		3.230	
AMMONIA	SIE[b]	Nessler[c]	SIE	Nessler	SIE	Nessler	SIE	Nessler
Total Sample Weight (Milligrams)	9455	9305	19552	17922	27857	22483	18955	16570
Grains/DSCF	41.77	41.11	88.61	81.23	154.0	124.3	90.56	79.17
AMMONIUM NITRATE CALCULATED FROM AMMONIA[d]								
Total Sample Weight (Milligrams)	44494	43788	92009	84339	131092	105802	89198	77976
Grains/DSCF	196.6	193.5	417.0	382.2	724.6	584.8	426.2	372.5
EXCESS AMMONIA[e]								
Total Sample Weight (Milligrams)	9427	9277	19518	17888	27816	22442	18920	16536
Grains/DSCF	41.65	40.99	88.46	81.07	153.7	124.0	90.39	79.00

a Dry standard cubic feet @ 68°F, 29.92 inches Hg.

b Specific Ion Electrode Analysis method.

c Nessler (with preliminary distillation) analysis method.

d Ammonium nitrate (mg) = ammonia (mg) x 80/17.

e Excess ammonia = (Ammonium nitrate calculated from ammonia) - (ammonium nitrate measured directly, from Table 2-17) x 17/80.

TABLE 2-22

SUMMARY OF AMMONIA, CALCULATED AMMONIUM NITRATE
AND CALCULATED EXCESS AMMONIA MEASUREMENTS
ON GASES SAMPLED AT 50% ISOKINETIC EXITING NEUTRALIZER NO. 2 SCRUBBER
AT C F INDUSTRIES, INC.,
HARRISON, TENNESSEE

RUN NUMBER	RUN 4		RUN 5		RUN 6		AVERAGE	
DATE	06-21-79		06-21-79		06-21-79			
VOLUME OF GAS SAMPLED (DSCF) [a]	2.466		2.642		2.508		2.539	
AMMONIA	SIE [b]	NESSLER [c]	SIE	NESSLER	SIE	NESSLER	SIE	NESSLER
Total Sample Weight (Milligrams)	7145	6729	13932	13223	21435	16868	14171	12273
Grains/DSCF	44.71	42.11	81.38	77.24	131.9	103.8	86.1	74.60
AMMONIUM NITRATE CALCULATED FROM AMMONIA [d]								
Total Sample Weight (Milligrams)	33624	31666	65562	62226	100871	79379	66686	57757
Grains/DSCF	210.4	198.2	383.0	363.5	620.7	488.4	405.3	351.0
EXCESS AMMONIA [e]								
Total Sample Weight (Milligrams)	7124	6708	13907	13198	21407	16840	14146	12249
Grains/DSCF	44.58	41.98	81.23	77.09	131.7	103.6	85.98	74.45

a Dry standard cucic feet @ 68°F, 29.92 inches Hg.

b Specific Ion Electrode analysis method.

c Nessler (with preliminary distillation) analysis method.

d Ammonium nitrate (mg) = Ammonia (mg) X 80/17.

e Excess Ammonia = ((Ammonium nitrate calculated from Ammonia) - (Ammonium nitrate measured directly, from Table 2-17)) X 17/80.

As described in Section 2.9, TRC directly evaluated the CO_2 content of the neutralizer No. 1 scrubber inlet gas stream during each test run using the EPA orsat analyzer procedure. Since this scrubber system is essentially air tight, these inlet CO_2 concentrations were applied to both inlet and outlet Neutralizer No. 1 sampling data in order to calculate gas stream molecular weights.

Cyclonic flow was observed at the neutralizer scrubber outlets and cyclonic flow angles were measured using the pitot-nulling technique described in EPA Reference Method 1. During the actual sampling however flow angles were not employed (probe tip was not rotated directly into the gas flow). No corrections have been made to the calculated neutralizer scrubber flow data, so the volumetric and mass flowrates in these tables may be lower than the flowrates that actually exist in the stacks. Average flow angles of 47 and 51 degrees were measured at the Neutralizer No. 1 and No. 2 scrubber outlets, respectively. The flow angles measured at each traverse point are shown in Appendix E. Details on current techniques of cyclonic flow measuring and data handling are contained in Section 5.1 and Appendix E.

2.4 Evaporators

The ammonium nitrate and insoluable particulate data for the gas stream leaving the Calandria alone, and for the combined gas streams from both the Calandria and the air-swept falling-film (ASFF) evaporator, are shown in Tables 2-23 and 2-24, respectively. The ammonia data for these gas streams are shown in Tables 2-25 and 2-26, respectively.

TABLE 2-23

SUMMARY OF AMMONIUM NITRATE AND INSOLUBLE PARTICULATE MEASUREMENTS ON GASES EXITING THE CALANDRIA EVAPORATOR AT C F INDUSTRIES, INC., HARRISON, TENNESSEE

RUN NUMBER	Run 7	Run 8	Run 9	Average
DATE	06-22-79	06-22-79	06-22-79	
VOLUME OF GAS SAMPLED (DSCF)[a]	0.1561	0.1674	0.2054	0.1763
PERCENT MOISTURE BY VOLUME	99.77	99.78	99.73	99.76
AVERAGE STACK TEMPERATURE (^{o}F)	289	291	290	290
STACK VOLUMETRIC FLOWRATE (DSCFM)[b]	8.272	8.291	10.280	8.948
PERCENT ISOKINETIC	98.3	105.1	104.1	102.5
PRODUCTION RATE (TONS/HOUR)	17.2	17.5	17.7	17.5
INSOLUBLE PARTICULATE				
Total Sample Weight (Milligrams)	46.31	68.81	21.60	45.57
Grains/DSCF	4.578	6.343	1.623	3.989
Pounds/Hour	0.3246	0.4508	0.1430	0.3059
Pounds/Ton	0.01887	0.02576	0.00808	0.01748
AMMONIUM NITRATE PARTICULATE[c]				
Total Sample Weight (Milligrams)	541.0	565.0	768.2	624.7
Grains/DSCF	53.48	52.09	57.72	54.68
Pounds/Hour	3.792	3.702	5.086	4.194
Pounds/Ton	0.22047	0.21154	0.28734	0.23966
TOTAL PARTICULATE: INSOLUBLE AND AMMONIUM NITRATE				
Total Sample Weight (Milligrams)	587.3	633.8	789.8	670.3
Grains/DSCF	58.06	58.43	59.34	58.67
Pounds/Hour	4.117	4.152	5.229	4.500
Pounds/Ton	0.23936	0.23726	0.29542	0.25714

a Dry standard cubic feet @ 68^{o}F, 29.92 inches Hg.

b Dry standard cubic feet per minute.

c Specific Ion Electrode Analysis method. This method measures nitrate (NO_3^-); ammonium nitrate (mg) = nitrate (mg) x 80/62.

TABLE 2-24

SUMMARY OF AMMONIUM NITRATE AND INSOLUBLE PARTICULATE MEASUREMENTS ON COMBINED GASES EXITING BOTH THE CALANDRIA EVAPORATOR AND THE AIR-SWEPT FALLING-FILM EVAPORATOR AT C F INDUSTRIES, INC., HARRISON, TENNESSEE

RUN NUMBER	Run 7	Run 8	Run 9	Average
DATE	06-22-79	06-22-79	06-22-79	
VOLUME OF GAS SAMPLED (DSCF)[a]	19.85	19.09	19.63	19.52
PERCENT MOISTURE BY VOLUME	32.45	43.38	35.71	37.18
AVERAGE STACK TEMPERATURE (^{o}F)	311	313	315	313
STACK VOLUMETRIC FLOWRATE (DSCFM)[b]	3196	2728	3213	3046
PERCENT ISOKINETIC	113.2	127.5	111.4	117.4
PRODUCTION RATE (TONS/HOUR)	20.3	21.0	21.0	20.8
INSOLUBLE PARTICULATE				
Total Sample Weight (Milligrams)	44.78	21.03	12.80	26.20
Grains/DSCF	0.0348	0.0170	0.0101	0.0207
Pounds/Hour	0.9533	0.3975	0.2771	0.5404
Pounds/Ton	0.04696	0.01893	0.01320	0.02598
AMMONIUM NITRATE PARTICULATE[c]				
Total Sample Weight (Milligrams)	144.0	148.0	146.5	146.2
Grains/DSCF	0.1120	0.1196	0.1152	0.1156
Pounds/Hour	3.068	2.797	3.173	3.018
Pounds/Ton	0.15113	0.13319	0.15110	0.14510
TOTAL PARTICULATE: INSOLUBLE AND AMMONIUM NITRATE				
Total Sample Weight (Milligrams)	188.8	169.0	159.3	172.4
Grains/DSCF	0.1468	0.1366	0.1252	0.1363
Pounds/Hour	4.021	3.194	3.448	3.559
Pounds/Ton	0.19808	0.15210	0.16419	0.17111

a Dry standard cubic feet @ 68^{o}F, 29.92 inches Hg.

b Dry standard cubic feet per minute.

c Specific Ion Electrode Analysis method. This method measures nitrate (NO_3^-); ammonium nitrate (mg) = nitrate (mg) x 80/62.

TABLE 2-25

SUMMARY OF AMMONIA, CALCULATED AMMONIUM NITRATE AND CALCULATED EXCESS AMMONIA MEASUREMENTS ON GASES EXITING THE CALANDRIA EVAPORATOR AT C F INDUSTRIES, INC., HARRISON, TENNESSEE

RUN NUMBER	Run 7		Run 8		Run 9		Average	
DATE	06-22-79		06-22-79		06-22-79			
VOLUME OF GAS SAMPLED (DSCF) [a]	0.1561		0.1674		0.2054		0.1763	
STACK VOLUMETRIC FLOWRATE (DSCFM) [b]	8.272		8.291		10.28		8.948	
PRODUCTION RATE (TONS/HOUR)	17.2		17.5		17.7		17.5	
AMMONIA	**SIE[c]**	**Nessler[d]**	**SIE**	**Nessler**	**SIE**	**Nessler**	**SIE**	**Nessler**
Total Sample Weight (Milligrams)	6672	5802	6181	5841	8921	8278	7258	6640
Grains/DSCF	659.6	573.6	569.8	538.5	670.3	621.9	635.3	581.2
Pounds/Hour	46.77	40.67	40.49	38.27	59.06	54.80	48.73	44.58
Pounds/Ton	2.719	2.365	2.314	2.187	3.337	3.096	2.785	2.547
AMMONIUM NITRATE CALCULATED FROM AMMONIA [e]								
Total Sample Weight (Milligrams)	31398	27304	29087	27487	41981	38955	34155	31249
Grains/DSCF	3104	2699	2681	2534	3154	2927	2990	2735
Pounds/Hour	220.0	191.4	190.5	180.1	277.9	257.9	229.3	209.8
Pounds/Ton	12.79	11.13	10.89	10.29	15.70	14.57	13.10	11.99
EXCESS AMMONIA [f]								
Total Sample Weight (Milligrams)	6557	5687	6061	5721	8758	8115	7125	6508
Grains/DSCF	648.2	562.2	558.7	527.4	658.0	609.7	623.7	569.7
Pounds/Hour	45.96	39.86	39.70	37.48	57.98	53.72	47.84	43.69
Pounds/Ton	2.672	2.317	2.269	2.142	3.276	3.035	2.734	2.497

[a] Dry standard cubic feet @ 68°F, 29.92 inches Hg.

[b] Dry standard cubic feet per minute.

[c] Specific Ion Electrode Analysis method.

[d] Nessler (with preliminary distillation) analysis method.

[e] Ammonium nitrate (mg) = Ammonia (mg) X 80/17.

[f] Excess ammonia = {(Ammonium nitrate calculated from ammonia) - (Ammonium nitrate measured directly, from Table 2-23)} X 17/80.

TABLE 2-26

SUMMARY OF AMMONIA, CALCULATED AMMONIUM NITRATE AND CALCULATED EXCESS AMMONIA MEASUREMENTS ON COMBINED GASES EXITING BOTH THE CALANDRIA EVAPORATOR AND THE AIR-SWEPT FALLING-FILM EVAPORATOR AT C F INDUSTRIES, INC., HARRISON, TENNESSEE

RUN NUMBER	Run 7		Run 8		Run 9		Average	
DATE	06-22-79		06-22-79		06-22-79			
VOLUME OF GAS SAMPLED (DSCF)[a]	19.85		19.09		19.63		19.52	
STACK VOLUMETRIC FLOWRATE (DSCFM)[b]	3196		2728		3212		3045	
PRODUCTION RATE (TONS/HOUR)	20.3		21.0		21.0		20.8	
AMMONIA	SIE[c]	Nessler[d]	SIE	Nessler	SIE	Nessler	SIE	Nessler
Total Sample Weight (Milligrams)	8338	6182	6739	6185	10233	10203	8437	7523
Grains/DSCF	6.482	4.806	5.448	5.000	8.045	8.021	6.670	5.948
Pounds/Hour	177.6	131.7	127.4	116.9	221.5	220.8	174.1	155.2
Pounds/Ton	8.749	6.488	6.067	5.567	10.55	10.51	8.370	7.462
AMMONIUM NITRATE CALCULATED FROM AMMONIA[e]								
Total Sample Weight (Milligrams)	39238	29092	31713	29106	48155	48014	39702	35404
Grains/DSCF	30.51	22.62	25.64	23.53	37.86	37.75	31.39	27.99
Pounds/Hour	835.8	619.7	599.5	550.2	1042	1039	819.3	730.5
Pounds/Ton	41.17	30.53	28.55	26.20	49.62	49.48	39.39	35.12
EXCESS AMMONIA[f]								
Total Sample Weight (Milligrams)	8307	6151	6708	6154	10202	10172	8406	7492
Grains/DSCF	6.458	4.782	5.423	4.975	8.020	7.997	6.646	5.923
Pounds/Hour	176.9	131.0	126.8	116.3	220.8	220.2	173.5	154.6
Pounds/Ton	8.714	6.453	6.038	5.538	10.51	10.49	8.341	7.433

a Dry standard cubic feet @ 68°F, 29.92 inches Hg.

b Dry standard cubic feet per minute.

c Specific Ion Electrode Analysis method.

d Nessler (with preliminary distillation) analysis method.

e Ammonium nitrate (mg) = ammonia (mg) x 80/17.

f Excess ammonia = [(ammonium nitrate calculated from ammonia) - (ammonium nitrate measured directly, from Table 2-24)] x 17/80

Table 2-27 shows the results of subtracting the Calandria gas stream data from the combined Calandria and ASFF gas stream data to yield calculated mass flowrates for the ASFF alone. A possible explanation for the negative ammonium nitrate mass flowrates shown in Table 2-27 is that the measured ammonium nitrate concentrations and mass flowrates for the Calandria alone are erroneous (too high). This is consistent with fact that the SIE analysis method for ammonium nitrate (AN) is subject to positive error if the background ion concentration is high relative to the nitrate concentration. The very high concentrations of ammonia compared to AN concentrations in the Calandria gas stream could be sufficient to produce a positive interference in the AN analysis. This interference is discussed further in Section 5.0.

2.5 Particle Size Test Data

Particulate size distribution tests were performed on the prill tower scrubber and prill cooler scrubber inlet gas streams with a cascade impactor. No size distribution information was obtained, however, because essentially all of the particulate matter was caught in the pre-collector. The data for these particle sizing test runs is shown in Appendix F.

2.6 Visible Emissions

The prill tower scrubber outlet plume was monitored by certified visible emissions observers from TRC and CFI for approximately seven hours during the May 1979 test period. The 6-minute average opacity of the bluish-white plume ranged from 2 percent to 19 percent. The TRC data are shown graphically in Figure 2-1 and are tabulated in Appendix H.

TABLE 2-27

SUMMARY OF INSOLUBLE PARTICULATE, AMMONIUM NITRATE PARTICULATE AND AMMONIA CALCULATED* MASS FLOWRATES FROM THE AIR-SWEPT FALLING-FILM EVAPORATOR AT CF INDUSTRIES, INC., HARRISON, TENNESSEE

RUN NUMBER	Run 1		Run 2		Run 3		Average	
DATE	06-22-79		06-22-79		06-22-79			
STACK VOLUMETRIC FLOWRATE (DSCFM)[a]	3192		2720		3203		3036	
INSOLUBLE PARTICULATE								
Pounds/Hour	0.629		<0		0.134		0.234	
AMMONIUM NITRATE PARTICULATE								
Pounds/Hour	<0		<0		<0		<0	
TOTAL PARTICULATE								
Pounds/Hour	<0		<0		<0		<0	
MEASURED AMMONIA	SIE[b]	Nessler[c]	SIE	Nessler	SIE	Nessler	SIE	Nessler
Pounds/Hour	130.83	91.03	86.91	78.63	162.44	166.00	125.37	110.62

a Dry standard cubic feet per minute @ 68°F, 29.92 inches Hg.

b Specific Ion Electrode Analysis method.

c Nessler (with preliminary distillation) analysis method.

* All data on this table were calculated as follows: ASFF (this table) = Combined (Tables 2-24 and 2-26) - Calandria (Tables 2-23 and 2-25).

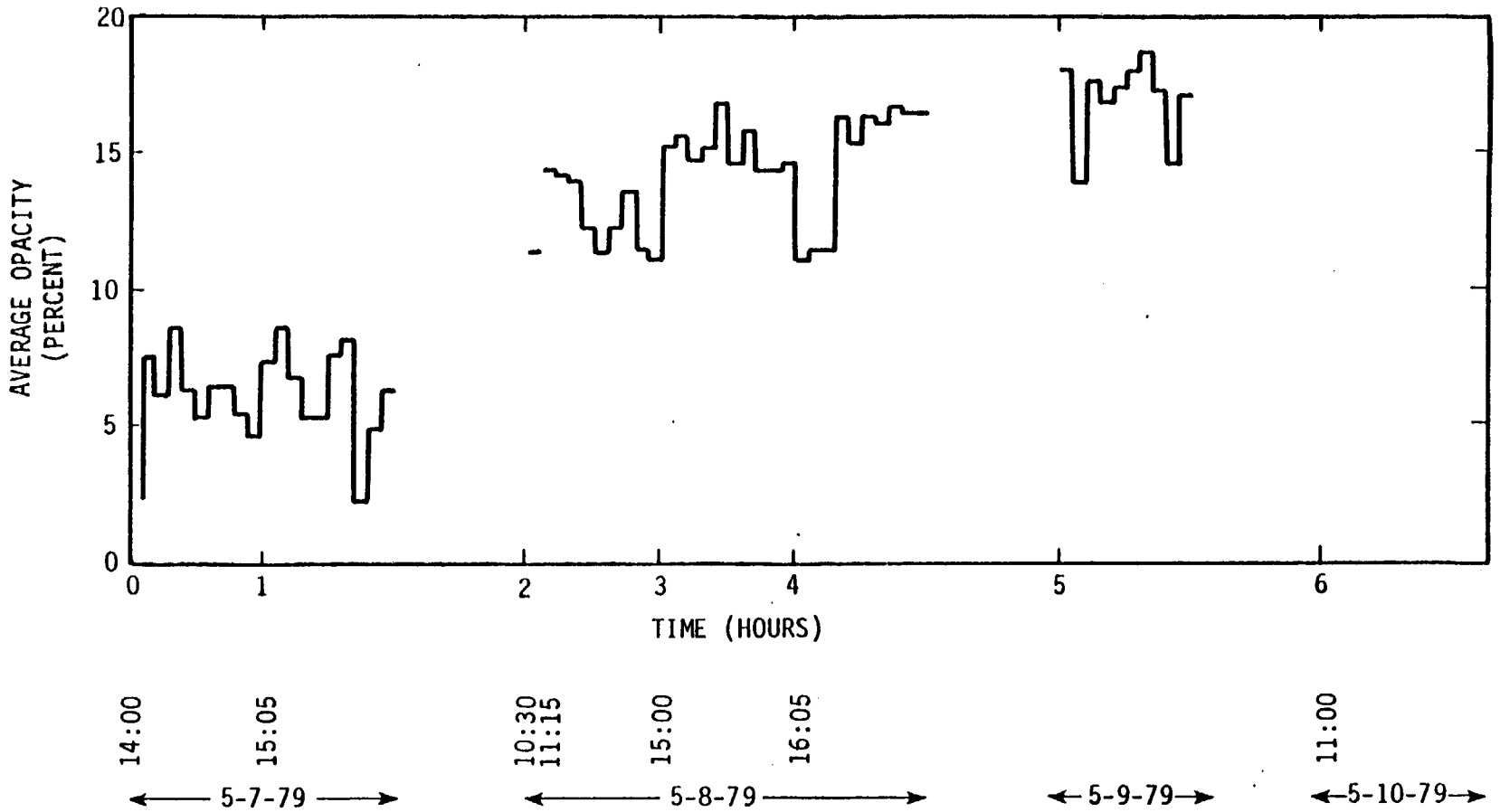

FIGURE 2-1: OPACITY READINGS ON THE PRILL TOWER SCRUBBER OUTLET AT C F INDUSTRIES, INC., HARRISON, TENNESSEE

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The two prill cooler scrubber outlet plumes were observed simultaneously for three hours during the May testing period by certified TRC and CFI observers, and all observations were zero. The combined plumes from the two neutralizer scrubber outlets were monitored for five hours during the June test period by both TRC and CFI observers, and these observations were also all zero. The TRC prill cooler scrubber and neutralizer scrubber data are shown tabulated in Appendix H.

2.7 Scrubber Liquor Analysis Data

Half-liter samples of scrubber liquor from the prill tower scrubber sump, the prill cooler scrubber system inlet and outlet, and the neutralizer No. 1 scrubber inlet were taken approximately every 30 minutes during each emission test run. The analysis data for these samples are shown in Tables 2-28, 2-29 and 2-30, respectively.

The solution temperature was measured immediately after each sample was taken; the pH was measured when the sample had cooled to room temperature. At the completion of each test run the individual samples obtained during that run were combined into one composite sample and analyzed for ammonia, ammonium nitrate, undissolved solids, and, in the case of one prill tower scrubber sample, magnesium.

2.8 Scrubber Pressure Drop Measurements

Pressure drop measurements were made across the prill tower scrubber, prill cooler scrubber and neutralizer No. 1 scrubber during the emission test runs. These data are shown in Tables 2-31 (prill tower), 2-32 (prill cooler east), 2-33 (prill cooler west) and 2-34 (neutralizer number 1). The following data show the pressure drop ranges observed at each location.

TABLE 2-28

SUMMARY OF MEASUREMENTS ON THE PRILL TOWER SCRUBBER LIQUOR
AT C F INDUSTRIES INC.,
HARRISON, TENNESSEE

Date	Run Number	Time	pH	Temp. (^{o}F)	Measurements Made on Combined Samples (PPM)				
					SIE[a] Ammonia	Nessler[b] Ammonia	Ammonium Nitrate[a]	Magnesium[c]	Undissolved Solids*
5-8-79	1	1120	7.30	80					
		1150	7.25	81					
		1223	7.25	81					
		1250	7.20	81					
		1320	7.05	81					
		Average	7.21	81	115000	97895	507000	311	18.2
	2	1520	7.30	81					
		1550	7.20	80					
		1620	7.30	80					
		1650	7.30	80					
		Average	7.28	80	117000	105250	535400		13.0
5-9-79	3	0930	6.50	79					
		0955	6.50	79					
		1030	6.50	79					
		1100	6.50	80					
		1200	6.50	80					
		Average	6.50	79	73000	69125	363800		6.0

a Specific Ion Electrode Analysis method.

b Nessler (with preliminary distillation) analysis method.

c Analyzed by atomic absorption.

* Milligrams per liter.

TABLE 2-29

SUMMARY OF MEASUREMENTS MADE ON PRILL COOLER SCRUBBER LIQUOR
AT C F INDUSTRIES, INC., HARRISON, TENNESSEE

			INLET						OUTLET					
			Measurements Made on Combined Samples (PPM)						Measurements Made on Combined Samples (PPM)					
						Ammonia						Ammonia		
Date	Run No.	Time	pH	Temp. (°F)	SIE[a]	Nessler[b]	Ammonium Nitrate[a]	Undissolved Solids*	pH	Temp. (°F)	SIE	Nessler	Ammonium Nitrate	Undissolved Solids*
5-10-79	4	1208	6.20	84					6.25	83				
		1238	6.35	86					6.40	86				
		1308	6.40	86					6.35	86				
		1350	6.40	86					6.35	86				
		1430	6.45	86					6.50	86				
		Average	6.36	86	4400	4800	2300	1.3	6.37	84	4400	4400	2300	2.3
5-11-79	5	0900	6.30	84					6.40	82				
		0940	6.55	83					6.40	85				
		1020	6.30	85					6.40	85				
		1100	6.60	84					6.50	86				
		1130	6.60	88					6.55	86				
		Average	6.47	85	5000	4600	2480	2.0	6.45	85	5000	4400	2450	3.2
5-11-79	6	1410	6.45	86					6.50	87				
		1450	6.45	86					6.40	88				
		1530	6.50	86					6.40	88				
		1605	6.45	86					6.40	88				
		1630	6.50	86					6.45	88				
		Average	6.47	86	6600	6000	3100	3.0	6.43	88	6700	6300	3250	4.4

[a] Specific Ion Electrode Analysis method.

[b] Nessler (with preliminary distillation) analysis method.

* Milligrams per liter.

TABLE 2-30

SUMMARY OF MEASUREMENTS MADE ON THE NEUTRALIZER NO. 1 SCRUBBER INLET LIQUOR AT C F INDUSTRIES, INC., HARRISON, TENNESSEE

Date	Run Number	Time	pH	Temp. °F	Measurements Made on Combined Samples (ppm)			
					SIE[a] Ammonia	Nessler[b] Ammonia	Ammonium Nitrate[a]	Undissolved Solids*
6-19-79	1	1545	8.60	168				
		1610	8.80	175				
		1650	8.80	190				
		Average	8.73	178	16120	12900	70950	6.9
6-20-79	2	1040	8.80	170				
		1110	8.80	170				
		1130	8.80	182				
		Average	8.80	174	19400	12010	76760	1.9
6-20-79	3	1325	8.90	170				
		1345	8.85	178				
		1405	8.90	180				
		Average	8.89	176	18900	14970	78690	1.6

a Specific Ion Electrode Analysis method.

b Nessler (with preliminary distillation) analysis method.

* Milligrams per liter.

TABLE 2-31

SUMMARY OF PRESSURE DROP MEASUREMENTS MADE ACROSS THE PRILL TOWER SCRUBBER AT C F INDUSTRIES, INC., HARRISON, TENNESSEE

Date	Run Number	Time	Pressure Drop (inches H_2O)	Date	Run Number	Time	Pressure Drop (inches H_2O)	Date	Run Number	Time	Pressure Drop (inches H_2O)
5-8-79	1	1114	10.6	5-8-79	2	1458	10.9	5-9-79	3	0908	10.8
		1129	10.4			1504	10.8			0911	10.8
		1138	10.4			1510	10.8			0914	11.0
		1144	10.4			1513	10.8			0934	10.8
		1159	10.6			1516	10.8			0937	10.8
		1202	10.4			1522	10.8			0940	10.8
		1208	10.4			1525	10.8			0943	10.8
		1223	10.6			1528	10.8			0946	10.8
		1226	10.6			1534	10.9			0949	10.6
		1238	10.7			1537	10.9			0952	10.9
		1241	10.7			1540	10.9			0955	10.9
		1247	10.6			1543	10.9			0958	10.9
		1250	10.6			1546	10.9			1001	10.9
		1259	10.7			1549	10.9			1004	10.9
		1305	10.7			1552	10.8			1007	10.9
		1314	10.7			1558	10.8			1010	10.9
		1320	10.7			1601	10.8			1013	10.9
		1329	10.6			1604	10.9			1016	10.9
		1332	10.6			1636	10.9			1019	10.8
		1335	10.6			1639	10.9			1022	10.6
						1642	10.9			1025	10.6
		Average	10.6			1645	10.9			1028	10.6
						1648	10.9			1042	10.6
						1651	10.8			1045	10.7
						1700	10.9			1048	10.7
						1706	10.9			1051	10.6
						1709	10.9			1054	10.6
						1718	10.8			1057	10.6
						1721	10.8			1100	10.4
						1724	10.9			1103	10.4
						1727	10.9			1132	10.2
						1733	10.9			1135	10.2
						1736	10.9			1138	10.5
						1739	10.9			1141	10.5
						1742	10.9			1144	10.5
						1745	10.9			1147	10.5
										1150	10.5
						Average	10.9			1153	10.5
										1156	10.5
										1159	10.5
										1202	10.5
										1205	10.5
										1208	10.5
										Average	10.7

TABLE 2-32

SUMMARY OF PRESSURE DROP MEASUREMENTS MADE ACROSS THE PRILL COOLER EAST SCRUBBER AT C F INDUSTRIES, INC., HARRISON, TENNESSEE

Date	Run Number	Time	Pressure Drop (inches H_2O)	Date	Run Number	Time	Pressure Drop (inches H_2O)	Date	Run Number	Time	Pressure Drop (inches H_2O)
5-10-79	4	1203	3.0	5-11-79	5	0906	3.5	5-11-79	6	1406	3.5
		1206	3.0			0909	3.5			1409	3.6
		1209	3.6			0912	3.5			1412	3.6
		1212	3.6			0915	3.5			1415	3.5
		1215	3.6			0918	3.6			1418	3.6
		1218	3.6			0921	3.6			1421	3.6
		1221	3.6			0924	3.6			1424	3.8
		1224	3.6			0927	3.6			1427	3.8
		1227	3.6			0930	3.7			1430	3.8
		1230	3.8			0933	3.7			1433	3.8
		1233	3.8			0936	3.7			1436	3.8
		1236	3.8			0939	3.7			1439	3.8
		1239	3.8			0942	3.7			1442	3.8
		1242	3.8			0945	3.7			1445	3.8
		1245	3.8			0948	3.7			1448	3.8
		1248	3.8			0951	3.7			1451	3.8
		1251	3.7			0954	3.7			1454	3.8
		1254	3.7			0957	3.7			1457	3.6
		1257	3.7			1000	3.7			1500	3.6
		1300	3.7			1003	3.7			1503	3.6
		1303	3.6			1006	3.6			1506	3.6
		1306	3.6			1009	3.6			1509	3.6
		1309	3.7			1041	3.7			1521	3.4
		1330	3.7			1044	3.8			1524	3.6
		1333	3.7			1047	3.8			1527	3.6
		1336	3.7			1050	3.8			1530	3.6
		1339	3.7			1053	3.8			1533	3.6
		1342	3.7			1056	3.8			1536	3.6
		1345	3.7			1059	3.8			1539	3.6
		1348	3.7			1102	3.8			1542	3.6
		1351	3.7			1105	3.8			1545	3.8
		1354	3.7			1108	3.8			1548	3.7
		1357	3.7			1111	3.8			1551	3.6
		1400	3.7			1114	3.8			1554	3.6
		1403	3.7			1117	3.8			1557	3.6
		1406	3.7			1120	3.8			1600	3.6
		1409	3.7			1123	3.8			1603	3.6
		1412	3.7			1126	3.8			1606	3.6
		1415	3.7			1129	3.8			1609	3.6
		1418	3.7			1131	3.8			1612	3.6
		1421	3.7			1134	3.8			1615	3.6
		1424	3.6			1137	3.8			1618	3.6
		1427	3.6			1140	3.6			1621	3.6
		1430	3.6			1143	3.6				
		1433	3.6			1146	3.6			Average	3.6
		Average	3.7			Average	3.7				

TABLE 2-33

SUMMARY OF PRESSURE DROP MEASUREMENTS MADE ACROSS THE PRILL COOLER WEST SCRUBBER AT C F INDUSTRIES, INC., HARRISON, TENNESSEE

Date	Run Number	Time	Pressure Drop (inches H_2O)	Date	Run Number	Time	Pressure Drop (inches H_2O)	Date	Run Number	Time	Pressure Drop (inches H_2O)
5-10-79	4	1200	4.4	5-11-79	5	0845	4.4	5-11-79	6	1403	4.2
		1215	4.5			0900	4.4			1415	4.3
		1230	4.5			0915	4.3			1430	4.2
		1245	4.5			0930	4.3			1445	4.2
		1300	4.5			0945	4.3			1500	4.2
		1315	4.5			1000	4.3			1515	4.2
		1327	4.5			1015	4.3			1530	4.2
		1330	4.5			1030	4.3			1545	4.2
		1345	4.5			1045	4.3			1600	4.2
		1400	4.5			1100	4.3			1615	4.2
		1415	4.5			1115	4.2				
		1430	4.5			1130	4.2			Average	4.2
						1146	4.2				
		Average	4.5								
						Average	4.3				

TABLE 2-34

SUMMARY OF PRESSURE DROP MEASUREMENTS
MADE ACROSS THE NEUTRALIZER NO. 1 SCRUBBER
AT CF INDUSTRIES, INC., HARRISON, TENNESSEE

Date	Run Number	Time	Pressure Drop	
			Inches H_2O	Inches Hg
6-19-79	1	1558	52.0	3.8
		1616	50.0	3.7
		1632	49.5	3.6
		1640	49.5	3.6
		1650	48.5	3.6
		1700	48.5	3.6
		Average	49.7	3.7
6-20-79	2	1034	64.5	4.7
6-20-79	3	1333	56.0	4.1
		1339	57.0	4.2
		1344	57.0	4.2
		1359	58.0	4.3
		1409	58.0	4.3
		Average	57.2	4.2

Location	Pressure Drop Range
Prill tower scrubber	10.2 - 11.0 inches H_2O
Prill cooler scrubber (east)	3.0 - 3.8 inches H_2O
Prill cooler scrubber (west)	4.2 - 4.4 inches H_2O
Neutralizer No. 1	3.6 - 4.7 inches Hg

2.9 Integrated Gaseous Bag Samples

One single-point gaseous bag sample was taken directly from the neutralizer No. 1 scrubber inlet gas stream during each of the three neutralizer tests runs. Each sample was analyzed for CO_2 and O_2 within one hour of collection using the EPA Reference Method 3 Orsat analyzer procedure. The data obtained from these analyses are as follows:

Location	Run	Percent CO_2	Percent O_2
Neutralizer No. 1 Scrubber Inlet	1	80.5	4.5
	2	80.0	4.0
	3	77.0	4.5

2.10 Ambient Air Measurements

Ambient air temperature, relative humidity and barometric pressure were recorded periodically during each emissions test run at the prill tower scrubber, prill cooler scrubber, neutralizers and evaporators. These data are shown in Tables 2-35, 2-36 and 2-37, respectively.

2.11 Product Samples

Solid product samples were taken by TRC personnel during the prill tower scrubber and prill cooler scrubber emissions tests. These samples were

TABLE 2-35

SUMMARY OF AMBIENT AIR MEASUREMENTS MADE AT THE PRILL TOWER AT C F INDUSTRIES, INC., HARRISON, TENNESSEE

Date	Run Number	Time	Ambient Temp. °F	Relative Humidity %	Barometric Pressure Inches Hg
5-8-79	1	1030	73	69	29.3
		1045	74	67	29.3
		1100	76	62	29.3
		1115	77	59	29.3
		1130	78	60	29.3
		1145	78	60	29.3
		1200	79	64	29.3
		1215	78	60	29.3
		1230	78	60	29.3
		1245	80	64	29.3
		1300	80	54	29.3
		1315	80	54	29.3
		1330	80	54	29.3
		1345	80	54	29.3
		1400	80	54	29.3
		Average	78	60	29.3
	2	1415	80	54	29.3
		1430	79	57	29.3
		1445	79	57	29.3
		1500	77	59	29.3
		1515	77	59	29.3
		1530	76	62	29.3
		1545	76	62	29.3
		1600	76	62	29.3
5-8-79	2	1615	76	62	29.3
		1630	76	62	29.3
		1645	77	63	29.3
		1700	77	59	29.3
		1715	76	62	29.3
		1730	76	62	29.3
		Average	77	60	29.3
5-9-79	3	0915	73	73	29.3
		0930	74	74	29.3
		0945	75	70	29.3
		1000	75	70	29.3
		1015	76	70	29.3
		1030	76	74	29.3
		1045	78	63	29.3
		1100	78	63	29.3
		1115	78	63	29.3
		1130	78	63	29.3
		1145	79	60	29.3
		1200	80	61	29.3
		1215	82	58	29.3
		1230	81	57.5	29.3
		1245	81	57.5	29.3
		Average	78	65	29.3

TABLE 2-36

SUMMARY OF AMBIENT AIR MEASUREMENTS MADE AT THE PRILL COOLER AT C F INDUSTRIES, INC., HARRISON, TENNESSEE

Date	Run Number	Time	Ambient Temp. °F	Relative Humidity %	Barometric Pressure Inches Hg
5-10-79	4	1200	92	48	29.3
		1215	92	48	29.3
		1230	92	48	29.3
		1245	93	48.5	29.3
		1300	93	48.5	29.3
		1315	93	48.5	29.3
		1330	93	48.5	29.3
		1345	95	41.5	29.3
		1400	95	41.5	29.3
		1415	97	37.5	29.3
		1430	97	39.5	29.3
		1445	97	39.5	29.3
		1500	97	39.5	29.3
		Average	95	45	29.3
5-11-79	5	0900	85	56.5	29.3
		0915	85	56.5	29.3
		0930	87	53.5	29.3
		0945	88	51	29.3
		1000	88	51	29.3
		1015	88	51	29.3
		1030	88	51	29.3
5-11-79	5	1045	89	48.5	29.3
		1100	90	47	29.3
		1115	91	47.5	29.3
		1130	92	45	29.3
		1145	93	42.5	29.3
		Average	89	50	29.3
	6	1400	97	39.5	29.3
		1415	98	38	29.3
		1430	97	39.5	29.3
		1445	97	39.5	29.3
		1500	98	38	29.3
		1515	99	35.5	29.3
		1530	100	35	29.3
		1545	99	34.5	29.3
		1600	99	34.5	29.3
		1615	99	36.5	29.3
		Average	98	37	29.3

TABLE 2-37

SUMMARY OF AMBIENT AIR MEASUREMENTS MADE AT THE NEUTRALIZERS AND EVAPORATORS AT C F INDUSTRIES, INC., HARRISON, TENNESSEE

Date	Run Number	Time	Ambient Temp. °F	Relative Humidity %	Barometric Pressure Inches Hg
6-19-79	1	1633	94	34.5	29.6
		1645	98	34.0	29.6
		1654	95	34.0	29.6
		Average	96	34	29.6
6-20-79	2	1033	85	54.5	29.67
		1039	88	51.0	29.67
		1045	88	51.0	29.67
		1105	83	76.0	29.67
		1114	87	57.0	29.67
		1120	87	53.5	29.67
		Average	86	57	29.67
	3	1324	89	51.5	29.67
		1333	89	51.5	29.67
		1345	90	47.0	29.67
		1357	87	57.0	29.67
		Average	89	58	29.67
6-22-79	7	1036	84	62	
		1046	81	69	
		1051	81	69	
		Average	82	67	
	8	1322	85	53	
		1337	91	46	
		Average	88	49	
	9	1514	96	48	
		1524	90	41	
		1529	90	44	
		Average	92	44	

analyzed at the CFI plant for bulk density and sieve size within two hours of collection time. The time and location of the sampling, and the results of these analyses are shown in Tables 2-38 and 2-39.

Solid product samples were also taken by CFI personnel and were chemically analyzed by CFI. The results of these analyses are considered confidential by CFI and are not presented in this report.

Samples of the liquid ammonium nitrate (AN) solutions and feed melts were taken by CFI personnel periodically during all the emissions test runs. Sampled were the 85% AN solution from neutralizer No. 1 to the surge tank, the 85% AN solution from the surge tank to the Calandria, the 94% AN solution from the Calandria to the ASFF evaporator and the 99% AN feed melt from the ASFF evaporator to the prill tower. Chemical analyses were performed by CFI on the samples for pH, temperature, ammonia and ammonium nitrate. These analyses results are also considered confidential by CFI and are not presented in this report.

TABLE 2-38

SUMMARY OF SIEVE ANALYSIS AND BULK DENSITY MEASUREMENTS
ON THE SOLID PRODUCT SAMPLED BEFORE ENTERING THE PRILL COOLER
AT C F INDUSTRIES, INC., HARRISON, TENNESSEE

Run Number	1			2			3		
Date	5-8-79			5-8-79			5-9-79		
Time	1250			1525			1000		
	Mass (Grams)	% Total Mass	Cumulative % Total Mass	Mass (Grams)	% Total Mass	Cumulative % Total Mass	Mass (Grams)	% Total Mass	Cumulative % Total Mass
Total Sample To Sieves	159.51			201.38			203.73		
Sieve #6	0.12	0.1	100	0.58	0.3	100	1.14	0.56	100
Sieve #8	20.61	12.9	99.9	30.12	15.0	99.8	48.34	23.7	99.44
Sieve #10	39.93	25.0	87.0	55.74	27.7	84.8	65.61	32.2	75.74
Sieve #12	57.73	36.2	62.0	74.65	37.1	57.1	52.52	25.8	43.54
Sieve #14	30.43	19.1	25.8	30.32	15.1	20.0	31.96	15.7	17.74
Sieve #16	9.07	5.7	6.7	8.13	4.0	4.9	3.02	1.48	2.04
Bottom Pan	1.62	1.0	1.0	1.84	0.9	0.9	1.10	0.54	0.56
Total Mass on Sieves and Pan	159.51			201.38			203.69		
Bulk Density (Grams per 250 ml)	258.25			254.76			260.84		

TABLE 2-39

SUMMARY OF SIEVE ANALYSIS AND BULK DENSITY MEASUREMENTS ON THE SOLID PRODUCT LEAVING THE PRILL COOLER (BEFORE SCREENING) AT C F INDUSTRIES, INC., HARRISON, TENNESSEE

RUN NUMBER	1			1			2			2			3			3		
DATE	5-10-79			5-10-79			5-11-79			5-11-79			5-11-79			5-11-79		
TIME	1225			1225			0935			0937			1430			1430		
	Mass (grams)	% Total Mass	Cumulative % Total Mass	Mass (grams)	% Total Mass	Cumulative % Total Mass	Mass (grams)	% Total Mass	Cumulative % Total Mass	Mass (grams)	% Total Mass	Cumulative % Total Mass	Mass (grams)	% Total Mass	Cumulative % Total Mass	Mass (grams)	% Total Mass	Cumulative % Total Mass
TOTAL SAMPLE TO SIEVES	201.76			201.37			202.66			202.57			203.50			200.79		
SIEVE NO. 6	0.96	0.5	100	1.20	0.6	100	1.19	0.6	100	1.50	0.7	100	0.55	0.3	100	0.84	0.4	100
SIEVE NO. 8	42.48	21.0	99.5	48.42	24.0	99.4	42.99	21.2	99.4	54.26	26.7	99.3	26.59	13.0	99.7	33.49	16.6	99.6
SIEVE NO. 10	60.25	29.9	78.5	60.93	30.2	75.4	65.63	32.3	78.2	62.29	30.7	72.6	49.92	24.5	86.7	53.21	26.4	83.0
SIEVE NO. 12	57.62	28.6	48.6	57.05	28.2	45.2	65.38	32.2	45.9	54.84	27.0	41.9	77.68	38.1	62.2	69.55	34.6	56.6
SIEVE NO. 14	32.22	16.0	20.0	28.12	13.9	17.0	19.94	9.82	13.7	22.32	11.0	14.9	38.25	18.8	24.1	34.44	17.1	22.0
SIEVE NO. 16	7.21	3.6	4.1	5.33	2.6	3.1	7.29	3.6	3.9	6.14	3.0	3.9	9.33	4.6	5.3	7.46	3.7	4.9
BOTTOM PAN	1.02	0.5	0.4	0.85	0.4	0.4	0.54	0.3	0.3	1.76	0.9	0.9	1.47	0.7	0.7	2.29	1.1	1.1
TOTAL MASS ON SIEVES AND PAN	201.76			201.90			202.96			203.11			203.79			201.28		
BULK DENSITY (grams per 250 ml)	257.94			250.10			258.47			248.25			258.51			248.8		

3.0 PROCESS DESCRIPTION AND OPERATION

Emission measurements were made at the CF Industries, Inc., Chattanooga Nitrogen Complex facility in Harrison, Tennessee during May and June 1979 in order to obtain data necessary for the development of a new source performance standard for the ammonium nitrate (AN) manufacturing industry. This plant is considered to employ process and emission control technology representative of high density AN prilling, rotary drum cooling, and modern AN solution production and concentration processes.

Figure 3-1 presents a flow diagram of the entire AN production process, and Figure 3-2 shows more detail of the AN solution production and concentration process. The emissions tests were designed to characterize and quantify uncontrolled emissions from the solids production processes (Prill Tower and Prill Cooler: May 8 - 11) and the solution production processes (Neutralizers and Evaporators: June 19 - 22), and to determine emission control equipment efficiency. During the emissions tests, process parameters pertinent to the operation of the various production streams were monitored in order to determine if the process was operating at representative steady-state conditions. Emission test locations and process product sampling locations are indicated by T and S, respectively, in Figures 3-1 and 3-2.

3.1 Process Equipment

Nitric acid at a concentration of approximately 58% by weight and ammonia-rich off-gas from the 120 ton per day (108.9 x 10^3 kg/hr) once through urea plant are fed to two parallel neutralizers. Additional ammonia, when needed, can be supplied from ammonia vaporizers. Ammonia-rich urea plant off-gas is preferred since this gas has no other use in the facility and would

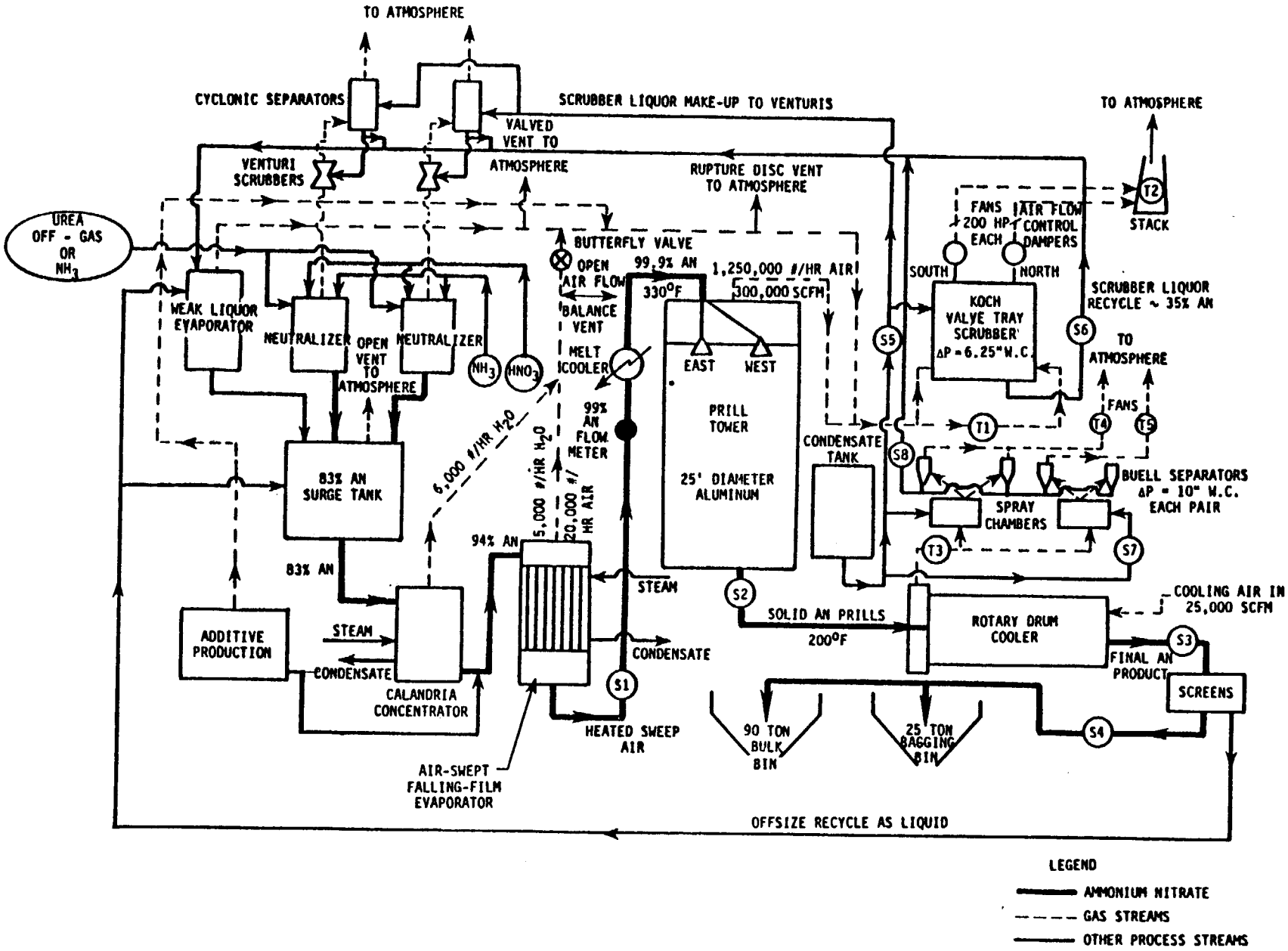


FIGURE 3-1: HIGH DENSITY AMMONIUM NITRATE PRODUCTION AT C F INDUSTRIES, INC., HARRISON, TENNESSEE

0988-003

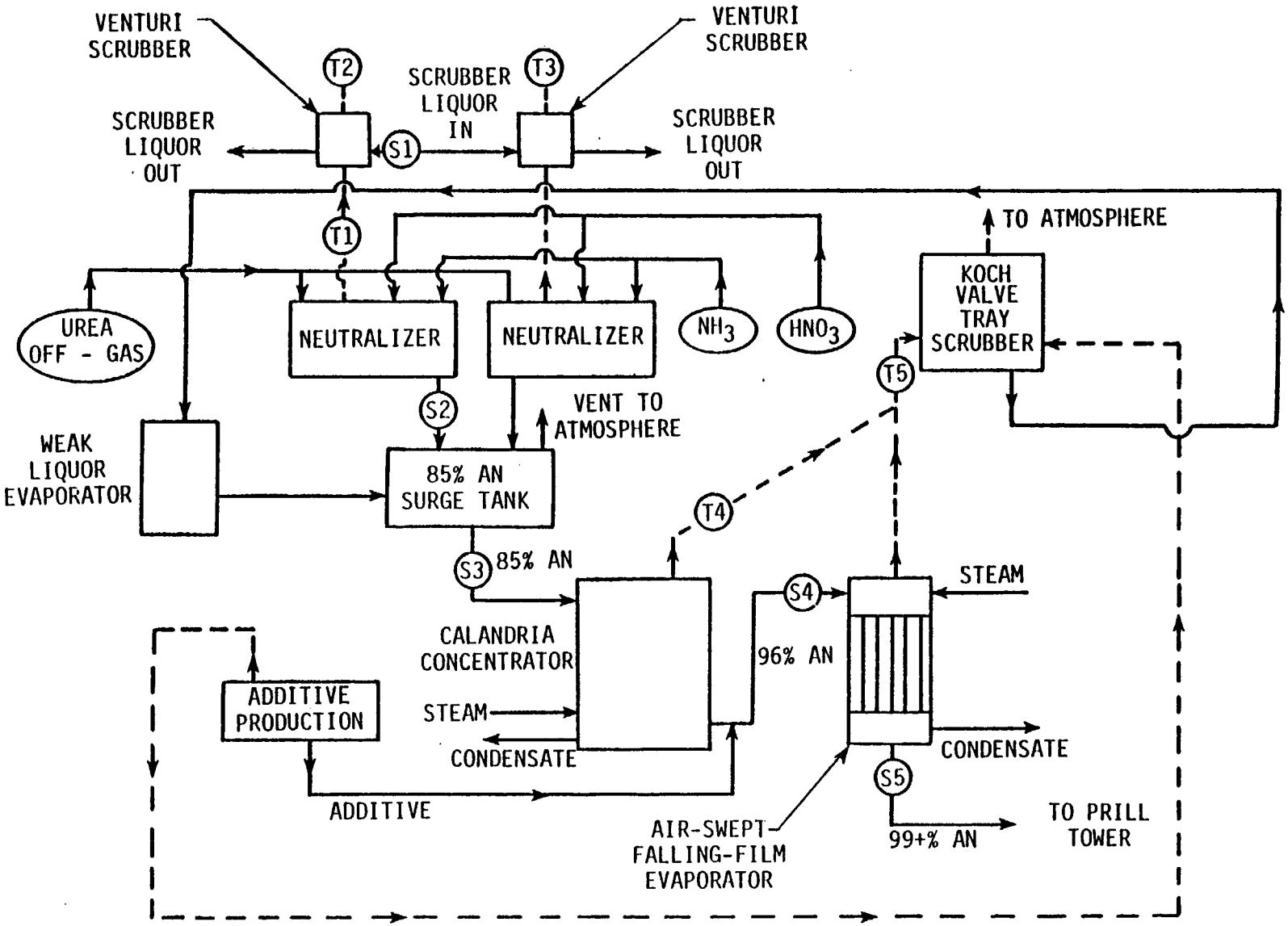


FIGURE 3-2: AMMONIUM NITRATE SOLUTION PRODUCTION AND CONCENTRATION LINE, AT CF INDUSTRIES, INC., HARRISON, TENNESSEE

0988-004

otherwise be wasted. The plant considered their neutralizers to be of the atmospheric type because they operate at an internal pressure of about 5 psig. The neutralizer pH is generally between 6.3 and 7.0.

The 85% AN solution produced in the neutralizers flows into a common surge tank. This surge tank also received recycled AN solution from the weak-liquor evaporator. (The weak-liquor evaporator is a Calandria and receives recycled scrubber liquors and redissolved off-size product rejected by the screening operation.)

The AN solution leaving the 85% AN surge tank is passed through a shell and tube steam-heated Calandria for the first stage of concentration to a nominal 96% AN concentration. The solution is then sent to the 96% AN surge tank.

From the 96% AN surge tank, the AN solution is sent through an air-swept falling-film evaporator for second stage concentration to a nominal 99.4 to 99.9% by weight AN concentration.

Magnesium nitrate additive is injected into the 96% AN solution immediately before the second stage of concentration at a rate of 0.5% by weight as MgO or 1.85% by weight as $Mg(NO_3)_2$. This additive serves three purposes: it increases the crystalline transition temperature of the solid final product from 89°F (32°C) to 120°F (49°C); it acts as a dessicant to draw water into the final product prills, thus reducing caking; and it allows prilling to be conducted at a lower temperature by reducing the molten AN salting-out temperature.

The 99+ percent melt is pumped through jacketed pipe to the top of the 25-foot diameter aluminum Prill Tower. Either steam or weak condensate can be pumped through the jacket, depending upon whether heating or cooling is

required. The AN droplets fall downward countercurrent to an induced air flow in the Prill Tower. The prills are collected at the bottom of the Tower on a belt conveyor. The solid prill product is then conveyed to a rotary drum cooler.

The rotary drum cooler reduces the AN prill temperature while removing nominal amounts of residual moisture from the prills. This is accomplished by a stream of refrigerated air flowing countercurrent to the direction of the prill movement inside the cooler.

After the cooler, a vibrating screen sizes the prills. Over and under-size prills are redissolved and recycled to the weak liquor concentrator.

The cooled, correctly sized prills leave the screen and are belt-conveyed to either a 90-ton (81.6×10^3 kg) capacity bulk bin from which railcars or trucks can be loaded or a 25-ton (22.7×10^3 kg) capacity bulk bin used to supply the bagging operation.

3.2 Emission Control Equipment

Each neutralizer has been retrofitted with Monsanto "Brinks" H-V mist eliminators to lessen the carry-over of raw materials and product. Venturi-cyclonic separator scrubbers have also been recently installed on each of the neutralizers. The 5 psig (3.4×10^4 Pa) internal operating pressure of the neutralizers provides enough force to operate the venturi scrubber at a pressure drop of approximately 55 inches (140 cm) vertical water column. Cyclonic separators immediately follow the venturis.

Along with the Prill Tower emissions, the first-stage Calandria Concentrator, the second-stage Air-Swept Falling-Film Evaporator, the weak-liquor concentrator, and the additive reactor vents are normally ducted

to a Koch valve tray scrubber. For these emission tests, however, these latter four process units were vented directly to the atmosphere so that only the Prill Tower emissions were applied to the Koch scrubber.

Four ducts collect the total air flow through the Prill Tower and carry it down the side of the Tower from where it is ducted over to the Koch valve tray scrubber. Contaminated air from the Prill Tower enters the bottom of the scrubber from two sides and must bubble up through two "valve" trays which are each flooded with 4 inches (10 cm) of scrubbing liquor. The valve trays operate in a similar manner to the bubble cap distillation principle.

The scrubbing liquor is maintained at 30 to 35 percent AN and is adjusted to a pH of between 6.7 and 7.6 by the addition of nitric acid. This plant has found that AN is not effectively scrubbed from the gas stream at a pH below 6 and ammonia is not scrubbed effectively above 7.8. The addition of nitric acid to the scrubber liquor enhances ammonia removal from the gas stream by promoting the formation of ammonium nitrate in the scrubber. Scrubber liquor is recycled to the weak-liquor concentrator for AN recovery.

Two fans, one 500 horsepower (3.73×10^5 watts) and one 600 horsepower (4.47×10^5 watts), operate in parallel and exhaust to a common stack. These fans induce the air flow through both the Prill Tower and the Koch scrubber and their associated ducting. Dampers in the ducts after the fans provide air flow rate control.

The rotary drum cooler exhaust air stream is divided into two separate streams. These air streams each enter a spray chamber. The air exiting each of the spray chambers is again divided into two streams (four streams total). Each stream tangentially enters a Buell cyclonic separator. Each of the

cyclonic separators as well as the spray chambers are irrigated with a weak ammonium nitrate solution. This scrubber solution as well as the Koch scrubber solution is recycled to the weak-liquor concentrator for AN recovery. Two fans induce the air flow through separate pairs of Buell units. The two fans in parallel also induce the chilled air flow through the cooler. The fans each exhaust through a separate stack.

3.3 Production Rate Monitoring

During emissions testing of Neutralizer No. 1 and its associated venturi-cyclonic separator unit, the nitric acid feed rate to the neutralizer was monitored and recorded. Since no other flow measuring device was available, the on-site nitric acid plant total production was piped directly to the two parallel neutralizers and the production rate was recorded. The nitric acid surge tank and its pump were bypassed so that the nitric acid production rates could be utilized as a measure of acid fed to the Neutralizer. By setting both neutralizer internal pressures equal to one another, equal production rates for each neutralizer were assured. This equalization of internal pressures was checked before each emission test. Total production rates for the neutralizers were calculated as 100% AN stoichiometrically from the equation:

$$NH_3 + HNO_3 \longrightarrow NH_4NO_3$$

and are as follows:

Average Neutralizer No. 1
Production Rates
During Emissions Tests

TEST	PRODUCTION RATE (Ton/Hr)	(Mg/Hr)
Scrubber Inlet and Outlet Test No. 1	11.26	10.21
Scrubber Inlet and Outlet Test No. 2	11.54	10.47
Scrubber Inlet and Outlet Test No. 3	11.43	10.37

During emissions testing of the two-stage concentrators, direct reading flow meters were utilized. The 85% AN solution flow rate to the first-stage Calandria Concentrator and the 99% AN solution flow rate from the second-stage Air-Swept Falling-Film Concentrator were monitored and recorded. Actual production rates were calculated as 100% AN and are as follows:

Average Concentrator
Production Rates
During Emissions Tests

TEST	PRODUCTION RATE (Ton/Hr)	(Mg/Hr)
Uncontrolled Calandria Test No. 1	17.18	16.14
Uncontrolled Calandria Test No. 2	17.51	15.89
Uncontrolled Calandria Test No. 3	17.66	16.02
Uncontrolled Air-Swept Falling-Film Test No. 1	20.30	18.42
Uncontrolled Air-Swept Falling-Film Test No. 2	20.99	19.04
Uncontrolled Air-Swept Falling-Film Test No. 3	20.99	19.04

Ammonia (NH_3) is injected into the high density evaporator and the head house at the top of the Prill Tower. This is done to inhibit the dissociation (fuming) of AN melt and reportedly cuts down on fine particulate formation. Testing of the Prill Tower scrubber was conducted both with and without ammonia injection. The ammonia injection status during each test was as follows:

Ammonia Injection Status
During Each Test

TYPE OF TEST	TEST 1	TEST 2	TEST 3
Prill Tower Emissions	on	on	off
Prill Tower Particle Size	off	on	on
Cooler Emissions	off	off	on
Cooler Particle Size	off	off	on

The feed rate of concentrated ammonium nitrate melt to the Prill Tower as measured by a volumetric flow meter was monitored and recorded. Actual production rates are determined from this feed rate and a conversion equation given by the plant. Since all of the prills leaving the Prill Tower go directly to the cooler and no other product rate measuring devices are present, the AN melt feed rate to the Prill Tower was used in calculating production rates for the cooler. Average Prill Tower production rates during testing of the Prill Tower and Prill Cooler scrubbers are as follows:

Average
Prill Tower Production Rates
During
Prill Tower Scrubber and Prill Cooler Scrubber
Testing

TEST	PRILL TOWER TESTING		PRILL COOLER TESTING	
	(Tons/Hr)	(Mg/Hr)	(Tons/Hr)	(Mg/Hr)
Scrubber Inlet and Outlet Test No. 1	21.0	19.1	21.0	19.1
Scrubber Inlet and Outlet Test No. 2	21.0	19.1	21.0	19.1
Scrubber Inlet and Outlet Test No. 3	21.3	19.3	20.7	18.9
Scrubber Inlet Particle Size Test No. 1	21.0	19.1	21.0	19.9
Scrubber Inlet Particle Size Test No. 2	21.0	19.1	21.0	19.1
Scrubber Inlet Particle Size Test No. 3	21.0	19.1	21.7	18.7

Appendix M contains the actual production rate calculations for all emissions tests.

3.4 Production and Control Equipment Monitoring

In addition to production rate determinations mentioned above, other parameters were also monitored. During emission testing of Neutralizer No. 1, the pH and temperature of both neutralizers, the 85% AN flow rate to the Calandria, the nitric acid tank level and feed pressure, and the 85% AN tank level were monitored and recorded.

During testing of the concentrators, the temperature and pressure of the steam to the Calandria and the temperature of the steam to the Air-Swept Falling-Film Evaporator were monitored and recorded.

Averages and standard deviations of all the above parameters monitored during the emissions tests have been calculated and are presented in Table 3-1.

During testing of the prill tower and its scrubber emissions, the temperature of the steam to the high density evaporator, the AN melt spray temperatures, the pressures of the two scrubber pumps, the north and south scrubber fan amperes, and the scrubber liquor pH were monitored and recorded.

During testing of the cooler and its scrubbers, the AN melt feed rate to the Prill Tower, the temperature of the steam to the high density evaporator, AN melt spray temperatures, cooler air inlet temperature, four scrubber pumps pressures, and scrubber liquor tank level were monitored and recorded.

Averages and standard deviations of all the above parameters monitored during the emissions tests have been calculated and are presented in Table 3-2 for Prill Tower tests, and Table 3-3 for cooler tests.

Standard deviations of parameters are not presented for a test where the number of parameter readings was three or less, unless the standard deviation is zero. All recorded parameter values are presented in Appendix M.

TABLE 3-1

AVERAGE VALUES OF NEUTRALIZER AND EVAPORATOR OPERATING PARAMETERS DURING EMISSIONS TESTING

		Neutralizer Number 1 Emissions Tests						Concentrator Emissions Tests					
		Test 1		Test 2		Test 3		Test 1		Test 2		Test 3	
		Avg.	Std. Dev.	Avg.	Std. Dev.	Avg.	Std. Dev.	Avg.	Std. Dev.	Avg.	Std. Dev.	Avg.	Std. Dev.
No. 1 Neutralizer pH		6.54	0.162	6.70	0.212	6.94	0.114						
No. 2 Neutralizer pH		7.67	0.197	7.64	0.055	8.0	0.071						
No. 1 Nuetralizer Temp	(^{o}F)	288.7	0.950	297.4	0.894	296.0	0.071						
	(^{o}C)	142.6	0.527	147.4	0.496	146.7	0.039						
No. 2 Neutralizer Temp	(^{o}F)	289.1	1.46	296.8	0.836	295.6	0.548						
	(^{o}C)	142.8	0.811	147.1	0.464	146.4	0.304						
85% AN Flow to Evap.	(gpm)	59	0.00	70.0	0.00	70	0.00	61.0	0.00	60.0	0.00	60.5	0.00
		223.3	0.00	264.9	0.00	264.9	0.00	230.9	0.00	227.1	0.00	229.0	0.00
Nitric Acid Feed Press	(psi)	62.7	5.09	19.2	0.273	19.5	0.00						
	(Pa x 10^5)	4.32	0.35	1.32	0.018	1.34	0.00						
Nitric Acid to Tank Level		61	0.00	49	0.00	49	0.00						
85% AN Tank Level		-	-	61	8.51	66.6	3.13						
99% AN Flow from Evap.	(gpm)							59.0	0.00	61.0	0.00	61.0	0.00
	(l pm)							223.3	0.00	230.9	0.00	230.9	0.00
Steam Temp to ASFF*	(^{o}F)							341.2	0.447	340.5	0.577	340.3	1.155
	(^{o}C)							171.7	0.248	171.4	0.32	171.3	0.641
Steam Temp to Calandria	(^{o}F)							333.2	1.643	337.0	0.00	341.0	0.00
	(^{o}C)							167.3	0.912	169.4	0.00	171.7	0.00
Stemp Press to Calandria	(psi)							121.3	0.447	123.0	1.154	128	0.00
	(Pa x 10^5)							8.35	0.031	8.48	0.079	8.83	0.00

*Air-Swept Falling-Film Evaporator

TABLE 3-2

AVERAGE VALUES OF PRILL TOWER OPERATING PARAMETERS DURING PRILL TOWER EMISSIONS TESTING

		Particulate Concentration Scrubber Inlet and Outlet Tests						Particle Size Tests					
		Test 1		Test 2		Test 3		Test 1		Test 2		Test 3	
		Avg.	Std. Dev.	Avg.	Std. Dev.	Avg.	Std. Dev.	Avg.	Std. Dev.	Avg.	Std. Dev.	Avg.	Std. Dev.
99% AN Melt to Tower	(gpm)	59.9	0.133	60	0.00	60.9	0.363	60	0.00	60	0.00	60	0.00
	(l pm)	226.7	0.503	227.1	0.00	230.5	1.37	227.1	0.00	227.1	0.00	227.1	0.00
Steam Temp. to H.D. Evap.	(^{o}F)	340	0.267	339.7	0.492	339.7	0.725	340	0.00	339	0.00	339.7	-
	(^{o}C)	171.1	0.148	170.9	0.273	170.9	0.403	171.1	0.00	170.6	0.00	170.9	-
Spray Temp. East	(^{o}F)	343	0.474	343	0.00	341.6	0.497	341	0.00	343	0.00	342.3	-
	(^{o}C)	172.7	0.263	172.7	0.00	172.0	0.276	171.7	0.00	172.7	0.00	172.4	-
Spray Temp. West	(^{o}F)	343	0.474	343	0.00	341.6	0.497	341	0.00	343	0.00	342.3	-
	(^{o}C)	172.7	0.263	172.7	0.00	172.0	0.276	171.7	0.00	172.7	0.00	172.4	-
No. 1 Scrubber Pump Pressure	(psig)	17.5	0.00	18	0.00	17	0.00	17	0.00	17	0.00	17	0.00
	(Pa x 10^{5})	1.21	0.00	1.24	0.00	1.17	0.00	1.17	0.00	1.17	0.00	1.17	0.00
No. 2 Scrubber Pump Pressure	(psig)	17.5	0.00	18	0.00	17	0.00	17	0.00	17	0.00	17	0.00
	(Pa x 10^{5})	1.20	0.00	1.24	0.00	1.17	0.00	1.17	0.00	1.17	0.00	1.17	0.00
South Fan Amps	(Amps)	70	0.00	70	0.00	70	0.00	70	0.00	70	0.00	70	0.00
North Fan Amps	(Amps)	85	0.00	85	0.00	85	0.00	85	0.00	85	0.00	85	0.00
Scrubber Liquor pH		-	-		0.00	6.83	-	6.85	-	7.6	0.00	7.6	0.00

TABLE 3-3

AVERAGE VALUES OF PRILL TOWER AND PRILL COOLER OPERATING PARAMETERS DURING COOLER EMISSIONS TESTING

		Particulate Concentration Scrubber Inlet and Outlets						Particle Size Tests					
		Test 1		Test 2		Test 3		Test 1		Test 2		Test 3	
		Avg.	Std. Dev.	Avg.	Std. Dev.	Avg.	Std. Dev.	Avg.	Std. Dev.	Avg.	Std. Dev.	Avg.	Std. Dev.
99% AN Melt to Tower (gpm) gal/min		60	0.00	59.4	0.51	59.4	0.50	60	0.00	60	0.00	59	0.00
(l pm)lit/min		227.1	0.00	224.8	1.93	224.8	1.89	227.1	0.00	227.1	0.00	223.3	0.00
Steam Temp. to H.D. Evap.	(°F)	339.5	0.687	341.0	2.33	341.2	1.16	341.3	-	340	0.00	342	0.00
	(°C)	170.8	0.381	171.6	1.29	171.7	0.64	171.8	-	171.1	0.00	172.2	0.00
Spray Temp. East	(°F)	343.4	1.12	342.9	0.99	346.2	1.33		0.00	340	0.00	344	0.00
	(°C)	168.0	0.622	172.7	0.55	174.5	0.739	175.5	0.00	172.2	0.00	173.3	0.00
Spray Temp. West	(°F)	334.4	1.12	342.9	0.99	346.2	1.33	348	0.00	344	0.00	344	0.00
	(°C)	168.0	0.622	172.7	0.55	174.5	0.739	175.5	0.00	173.3	0.00	173.3	0.00
Cooler Air Temp. In	(°F)	43.7	0.52	36.1	2.03	42.5	2.25	44	0.00	34	-	40	-
	(°C)	6.5	0.288	2.27	1.12	5.83	1.25	6.66	0.00	1.11	-	4.44	-
Scrubber Flow 1	(gpm)	6.2	0.26	6.0	0.00	6.0	0.00	6.0	0.00	6.0	-	6.5	-
	(l pm)	23.5	0.984	22.7	0.00	22.7	0.00	22.7	0.00	18.9	-	22.7	-
Scrubber Flow 2	(gpm)	6.0	0.00	5.0	0.00	5.5	0.00	6.0	0.00	5.0	-	5.5	-
	(l pm)	22.7	0.00	18.9	0.00	20.8	0.00	22.7	0.00	18.9	-	20.8	-
Scrubber Flow 3	(gpm)	6.0	0.00	6.0	0.00	6.0	0.00	6.0	0.00	6.0	0.00	6.0	-
	(l pm)	22.7	0.00	22.7	0.00	22.7	0.00	22.7	0.00	22.7	0.00	22.7	-
Scrubber Flow 4	(gpm)	4.2	1.2	4.8	0.75	4.8	0.75	4.5	-	4.5	-	6.0	-
	(l pm)	15.9	4.54	18.2	2.83	18.2	2.86	17.0	-	17.0	22.7	-	-
Scrubber Solution Tank Level	(inches)	25	0.00	25	0.00	25	0.00	25	0.00	25	0.00	25	0.00
	(cm)	63.5	0.00	63.5	0.00	63.5	0.00	63.5	0.00	63.5	0.00	63.5	0.00

3.5 General Plant Operation

Neutralizer and Concentrator Operation

Overall, the solution production and concentration line operated smoothly as the above data indicates. However, during the neutralizer testing, constant monitoring and adjusting of the neutralizer pH was necessary. The pH of both neutralizers never really "lined out", but plant personnel did not feel this would affect either the emissions or the product. Normal operation of the neutralizers includes a nitric acid surge tank and pump; perhaps the removal of this surge tank and pump increased the lag time of the pH controller and caused more fluctuations than normal. (For these emissions tests, this tank and pump were bypassed, thus allowing the nitric acid plant instrumentation to be used for neutralizer production rate determinations.)

A decreased production demand led to a substantially reduced Air-Swept Falling-Film Evaporator production rate between the first and second tests of this unit. (Since no warehouse exists, the product must be shipped very shortly after it is produced.) The unit's production rate had been increased before the first two tests. After the second test, it was decided not to turn down the rate until the testing was completed because of the amount of manpower to accomplish this.

Prill Tower Scrubber and Cooler Operation

Overall, the entire AN solids production line operated very smoothly, as Tables 3-2 and 3-3 indicate. However, during the first test of the Prill Tower scrubber, the opacity of the scrubber stack seemed to noticeably increase. The only explanation of this is that fumes from the neutralizer overhead vents were sucked into the Prill Tower air inlet. One of the two neutralizer overhead vents looked dirtier than the other until the liquor flow rate to its venturi scrubber was increased.

Problems with the CO_2 compressor in the 120 ton/day (108.8×10^3 kg/day) once-through urea plant caused that plant to shut down. Therefore, ammonia feed to the neutralizers had to be supplied from the ammonia vaporizers instead of the normal, ammonia-rich, urea off-gas. This problem occurred before the third test of the Prill Tower scrubber and was corrected before the test started.

4.0 LOCATION OF SAMPLING POINTS

This section presents descriptions of the sampling locations used during the emissions testing program conducted at the CF Industries, Inc., Harrison, Tennessee, ammonium nitrate plant during May and June 1979. During the week of May 7 - 11, 1979, the Prill Tower scrubber and Prill Cooler scrubber were evaluated. During the week of June 18 - 22, 1979, the neutralizer scrubbers and the evaporator emissions were evaluated. Figure 4-1 presents a simplified overhead view of the ammonium nitrate production facilities.

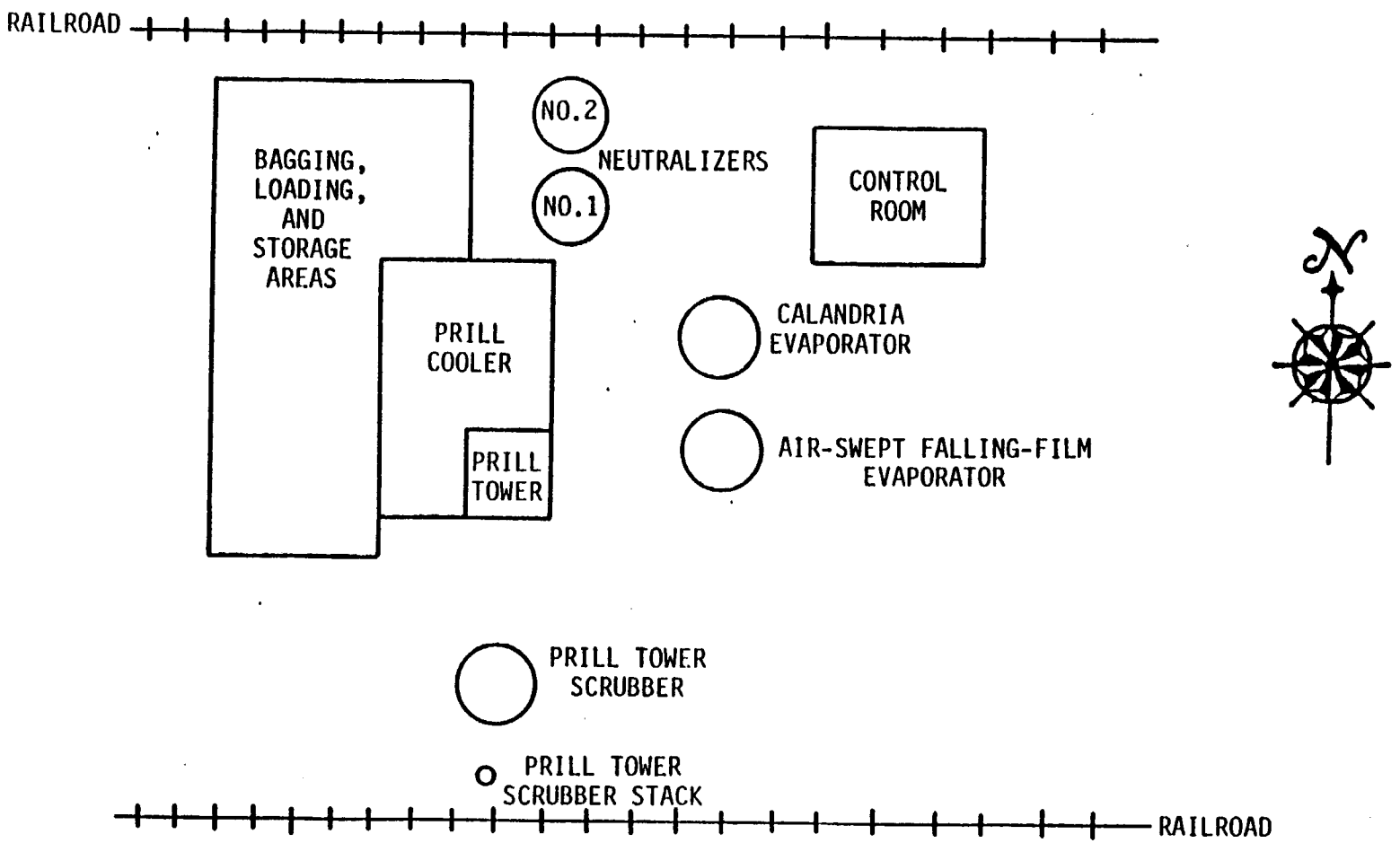
4.1 Prill Tower

4.1.1 Scrubber Inlet - Ammonium Nitrate Sampling

The scrubber inlet sampling site was located in a 117-3/4 inch I.D. horizontal fiberglass duct. A schematic of the sampling site, including the traverse point sampling locations and duct dimensions, is shown in Figure 4-2. Two 3-1/2 inch pipe-flange sampling ports positioned 90^{o} apart were located 14 feet 1 inch (1.4 duct diameters) upstream of a short radius right-angle bend. The nearest upstream disturbance was a contraction 40 feet (4.1 duct diameters) from the ports. Since this sampling site did not meet the "eight and two" criteria for distance from flow disturbances, eighteen sampling points were chosen for each axis traverse, for a total of 36 sampling points as specified in EPA Reference Method 1. Shown also in Figure 4-2 is a cross-sectioned view of the duct at the sampling location and the exact distance of each sampling point from the outside flange edge.

4.1.2 Scrubber Outlet - Ammonium Nitrate Sampling

The gases exiting the scrubber unit pass through two fans which direct the



NOT TO SCALE

FIGURE 4-1: GENERAL LAYOUT OF AMMONIUM NITRATE PROCESS FACILITIES AT CF INDUSTRIES, INC., HARRISON, TENNESSEE

0988-005

TRAVERSE POINT NUMBER	TRAVERSE POINT LOCATION FROM OUTSIDE OF NIPPLE (INCHES)
1	5-1/8
2	8-5/8
3	12-3/8
4	16-3/8
5	20-3/4
6	25-5/8
7	31-1/4
8	38-3/8
9	48-1/2
10	76-1/4
11	86-3/8
12	93-1/2
13	99-1/8
14	104
15	108-3/8
16	112-3/8
17	116-1/8
18	119-5/8

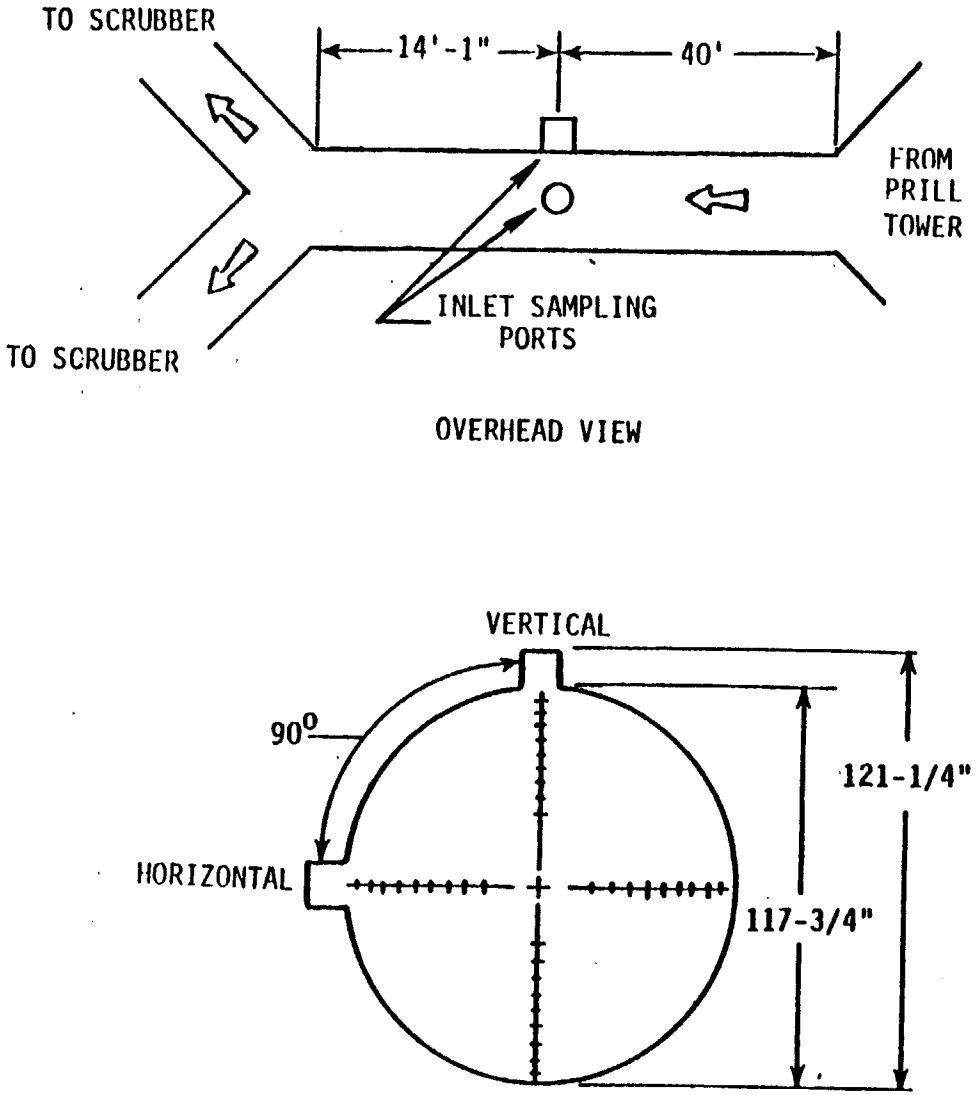


FIGURE 4-2: PRILL TOWER SCRUBBER INLET SAMPLING LOCATION AT CF INDUSTRIES, INC., HARRISON, TENNESSEE

0988-006-001

gases vertically through a fiberglass stack to the atmosphere. The scrubber outlet sampling site was located in a 119-1/2 inch vertical fiberglass duct. The stack was fitted with two 4-inch pipe-flange sample ports positioned 90° apart. The two ports were located 5 feet 9 inches (0.6 diameters) upstream from the top of the stack, and about 5 feet (0.5 diameters) downstream from a baffle inside the stack. EPA Method 1 was again followed to yield 24 sampling points for each axis traverse and a total of 48 sampling points in the stack. Figure 4-3 shows a schematic of this sampling site including a cross-sectioned view of the duct and the exact distance of each point from the outside flange edge.

4.1.3 Particle Sizing Tests at Scrubber Inlet

Particle sizing tests were performed in the Prill Tower scrubber inlet gas stream using a Sierra cascade impactor positioned in the duct through the test ports used for the ammonium nitrate sampling tests. The impactor nozzle was positioned at the geometric center of the duct for each impactor run.

4.1.4 Scrubber Pressure Drop Measurements

The gas pressure drop across the prill scrubber was measured with a water manometer connected to taps in the scrubber inlet duct and the scrubber outlet duct (upstream of the fans).

4.1.5 Scrubber Liquor Sampling

Scrubber liquor samples were taken from the scrubber sump downstream from the circulating pump. Figure 4-4 shows the location of this sampling point.

TRAVERSE POINT NUMBER	TRAVERSE POINT LOCATION FROM OUTSIDE OF NIPPLE (INCHES)
1	5-1/4
2	7-7/8
3	10-5/8
4	13-1/2
5	16-1/2
6	19-3/4
7	23-1/4
8	27-1/8
9	31-1/2
10	36-1/2
11	42-1/2
12	51-1/2
13	76
14	84-7/8
15	91
16	96
17	100-1/4
18	104-1/4
19	107-3/4
20	111
21	114
22	116-7/8
23	119-5/8
24	122-1/8

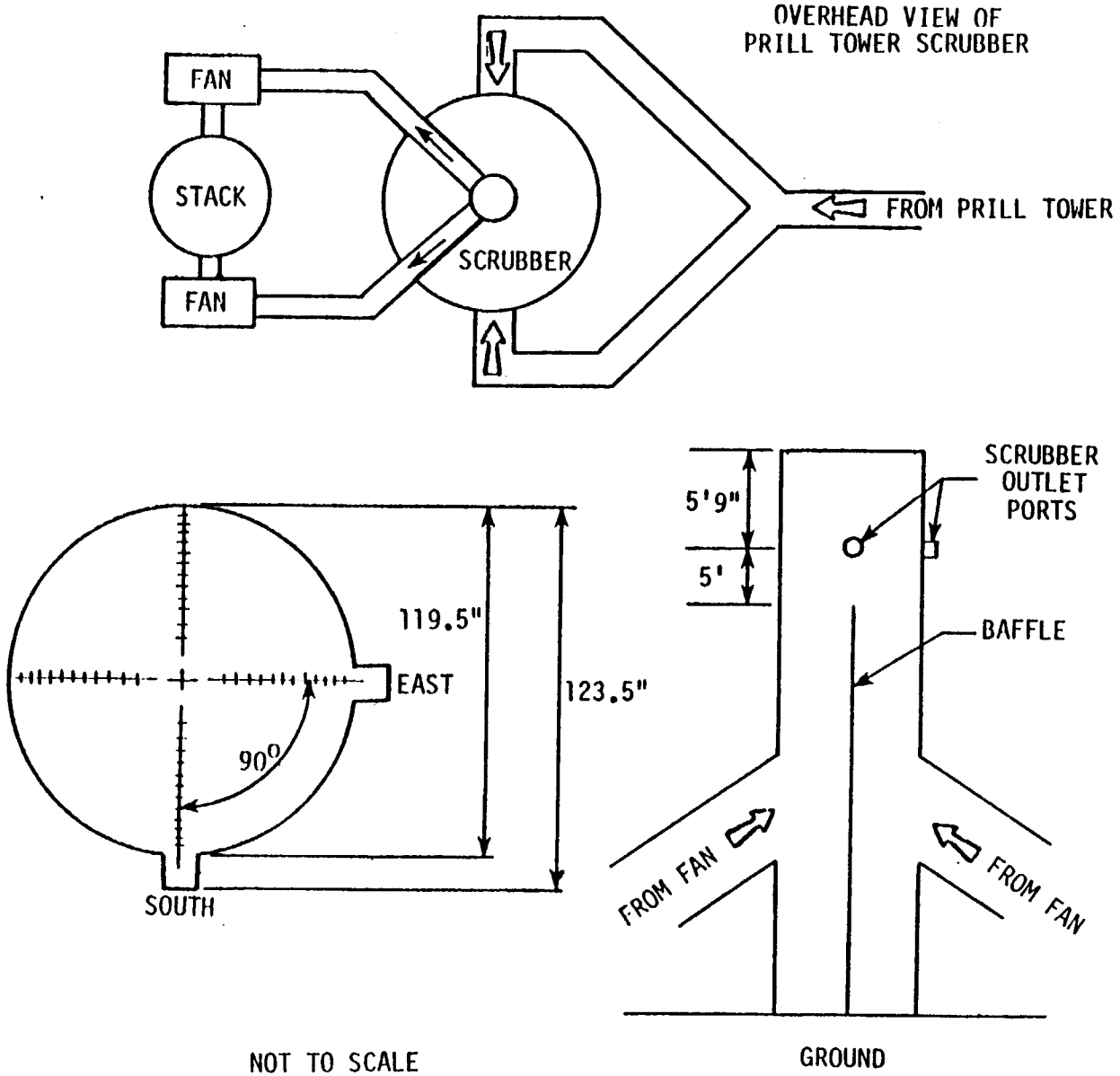


FIGURE 4-3: PRILL TOWER SCRUBBER OUTLET SAMPLING LOCATION AT CF INDUSTRIES, INC., HARRISON, TENNESSEE

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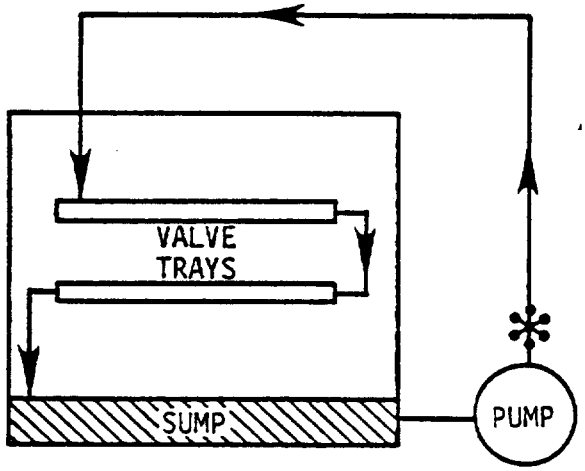
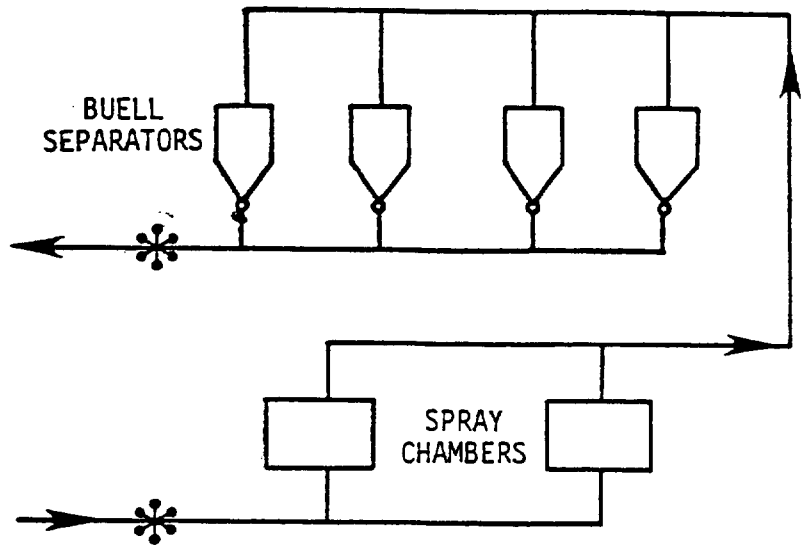
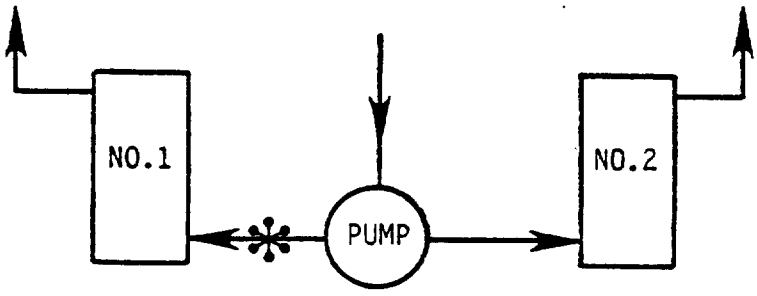


PRILL TOWER KOCH
VALVE TRAY SCRUBBER



PRILL COOLER SCRUBBER SYSTEM



NEUTRALIZER VENTURI
SCRUBBERS

✻ SAMPLING LOCATIONS

FIGURE 4-4: SCRUBBER LIQUOR SAMPLING LOCATIONS
AT CF INDUSTRIES, INC.,
HARRISON, TENNESSEE

0988-008

4.2 Prill Cooler

4.2.1 Scrubber Inlet - Ammonium Nitrate Sampling

The Prill Cooler inlet sampling site was located in a 30-inch I.D. horizontal section of a stainless steel duct. Two 3-inch pipe-flange sampling ports positioned 90° apart were located 21 inches downstream of a long radius bend. The nearest downstream disturbance was a short radius right angle bend 13 inches from the ports. Following the EPA Reference Method 1, 24 sampling points were located on each of the two traverse axis, to yield a total of 48 sampling points. Figure 4-5 shows a schematic of the sampling site including a cross-section of the duct and the exact location of each sampling point.

4.2.2 Scrubber Outlets - Ammonium Nitrate Sampling

The two Prill Cooler scrubber system outlet stacks (identified as East and West) are identical in size. The sampling site in each was a 36-inch I.D. vertical duct. Two 3-inch pipe flange sampling ports positioned 90° apart were located 9 feet (3.0 duct diameters) downstream from an interior fan. The nearest downstream disturbance was the top of the stack more than 6.0 feet (2.0 duct diameters) from the ports. This sampling location required a total of 48 sampling points, 24 on each traverse axis. The extreme points on each traverse (points #1, 24, 25 and 48) were within 1/2 inch of the stack wall. Due to an oversignt by the field test leaders these points were dropped from sampling, instead of being moved to and sampled at 1" from the stack wall as called for in EPA Reference Method #1. Figure 4-6 shows a schematic of this sampling location.

TRAVERSE POINT NUMBER	TRAVERSE POINT LOCATION FROM OUTSIDE OF NIPPLE (INCHES)
1	4
2	4
3	4-1/2
4	5-1/3
5	6-1/8
6	7
7	7-2/3
8	8-2/3
9	9-3/4
10	11-1/8
11	12-2/3
12	14-3/4
13	21
14	23-1/4
15	24-2/3
16	26
17	27-1/8
18	28-1/8
19	29
20	29-2/3
21	30-1/2
22	31-1/3
23	32
24	32

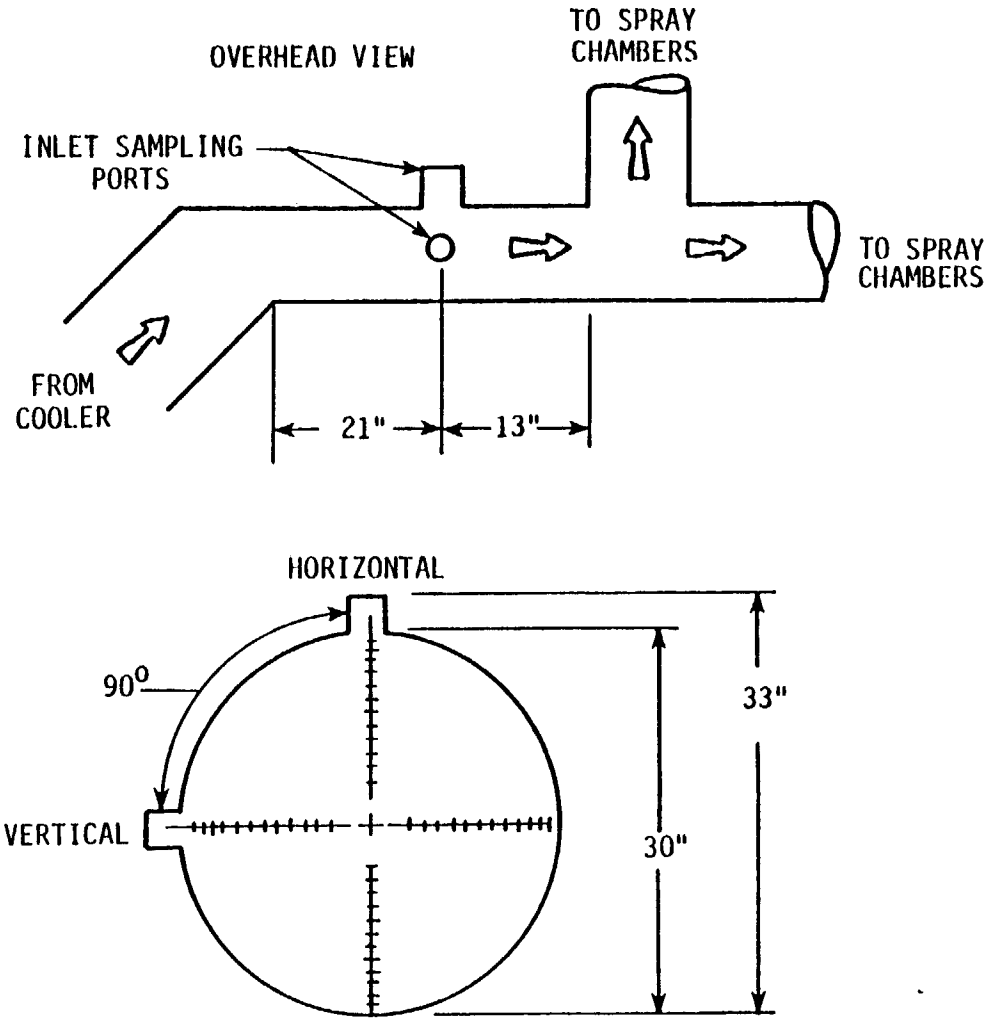
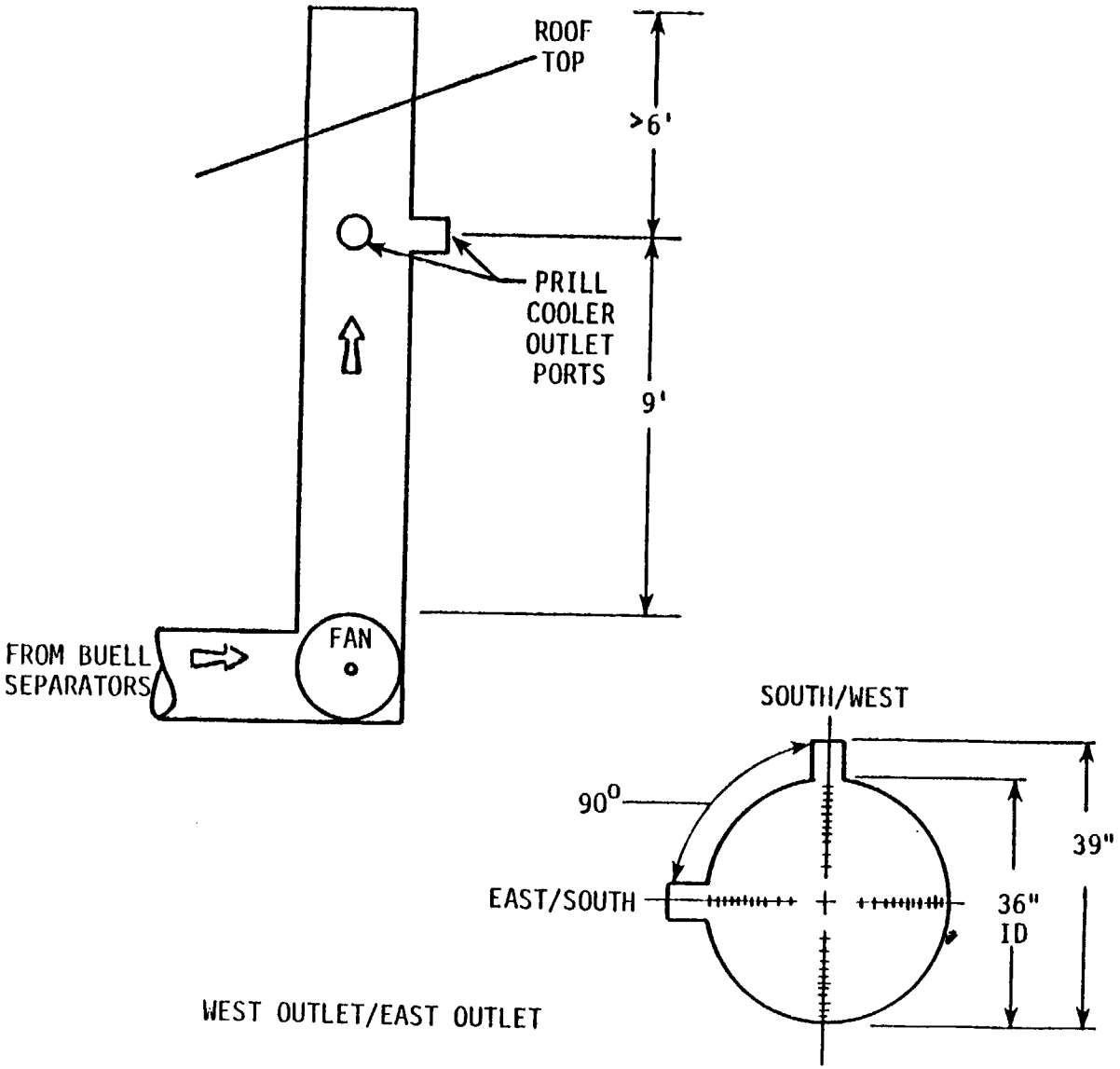


FIGURE 4-5: PRILL COOLER SCRUBBER INLET SAMPLING LOCATION AT CF INDUSTRIES, INC., HARRISON, TENNESSEE



TRAVERSE POINT NUMBER	TRAVERSE POINT LOCATION FROM OUTSIDE OF NIPPLE (INCHES)
1	4
2	4
3	4-1/4
4	5-3/16
5	6-1/8
6	7-3/16
7	8-1/4
8	9-1/2
9	10-7/8
10	12-7/16
11	14-3/8
12	17-1/8
13	24-7/8
14	27-5/8
15	29-5/8
16	31-3/8
17	32-1/2
18	33-3/4
19	34-7/8
20	35-7/8
21	36-3/4
22	37-7/8
23	38
24	38

FIGURE 4-6: PRILL COOLER OUTLET SAMPLING LOCATION (WEST AND EAST) AT CF INDUSTRIES, INC., HARRISON, TENNESSEE

4.2.3 Particle Sizing Tests at Scrubber Inlet

Particle sizing tests were performed in the Prill Cooler scrubber system common inlet gas stream using a Sierra cascade impactor positioned in the duct through the test ports used for the ammonium nitrate sampling. The impactor nozzle was positioned at the geometric center of the duct for each impactor run.

4.2.4 Scrubber Pressure Drop Measurements

The pressure drops across the Prill Cooler scrubber system were measured from the common gas stream inlet to the two outlet ducts, using two manometers. The inlet pressure tap was a stainless steel tube inserted through one of the ammonium nitrate sampling ports into the middle of the duct. The outlet taps were located adjacent to each fan inlet.

4.2.5 Scrubber Liquor Sampling

Scrubber liquor samples were taken from the common inlet liquor line (feeding both spray chambers) and from the common outlet liquor line returning from all four Buell separators. Figure 4-4 shows the location of these sampling points.

4.3 Neutralizers

4.3.1 Scrubber Inlet

The Neutralizer No. 1 venturi scrubber inlet sampling site was located in a 20-inch I.D. vertical section of stainless steel duct. Because of physical limitations at this location, only the southwest port with an extension was used. This port was located seven feet (4.2 duct diameters) from the nearest upstream flow disturbance (the neutralizer itself) and 22

inches (1.1 duct diameters) from the nearest downstream flow disturbance (a short radius right angle bend). On the one traverse axis, twelve sampling points were chosen, in accordance with EPA Reference Method 1. Figure 4-7 shows a schematic of this sampling location. A special sampling probe assembly was used to seal the port against the relatively high gas stream pressure.

The inlet on Neutralizer No. 2 venturi scrubber was not tested.

4.3.2 Scrubber Outlets

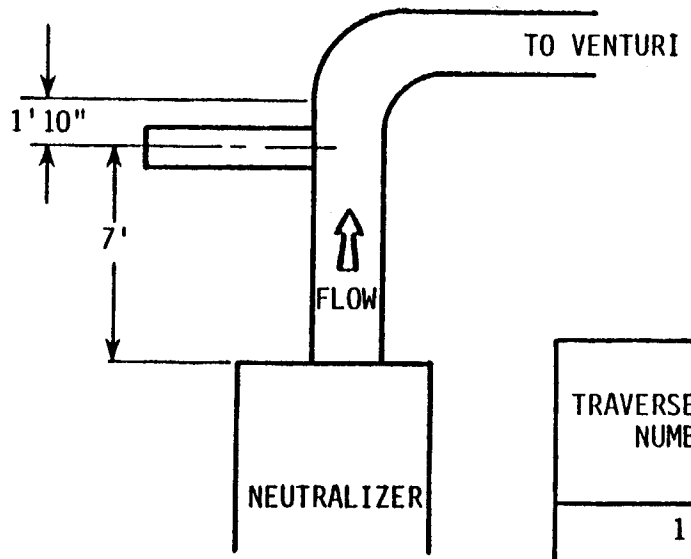
Both neutralizer scrubber outlets were tested, and both outlet stacks are identical. Each 19-1/2 inch I.D. vertical stack was fitted with two 3-1/2 inch pipe-flange sampling ports positioned 90^{o} apart. The ports were located 66-1/2 inches (3.4 duct diameters) downstream from a contraction, and 55 inches (2.8 duct diameters) upstream from the top of the stack.

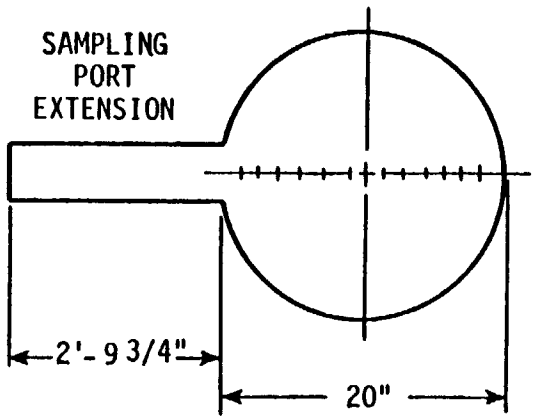
In Neutralizer No. 1 scrubber outlet, only the back half of each traverse axis could be used because of the physical limitations imposed by an in-stack orifice. On each axis 7 sampling points were chosen, for a total of 14 sampling points. Figure 4-8 shows a schematic of the Neutralizer Number 1 scrubber outlet sampling location.

One sampling point on each axis (one inch from the duct center) was used at the Neutralizer No. 2 scrubber outlet. Two probes were operated simultaneously: one probe sampling at 50% isokinetic and the other probe at 200% isokinetic. Figure 4-9 shows a schematic of this sampling location.

4.3.3 Scrubber Pressure Drop Measurements

The pressure drop across the Neutralizer No. 1 scrubber was measured with a manometer connected to taps in the scrubber inlet and outlet ducts.





TRAVERSE POINT NUMBER	TRAVERSE POINT LOCATION FROM OUTSIDE OF NIPPLE (INCHES)
1	34-1/8
2	35-1/16
3	36-3/16
4	36-2/8
5	38-3/4
6	40-7/8
7	46-5/8
8	48-3/4
9	50-1/4
10	51-3/8
11	52-7/16
12	53-3/8

FIGURE 4-7: NEUTRALIZER NO. 1 SCRUBBER INLET SAMPLING LOCATION AT CF INDUSTRIES, INC., HARRISON, TENNESSEE

TRAVERSE POINT NUMBER	TRAVERSE POINT LOCATION FROM OUTSIDE OF NIPPLE (INCHES)
1	4-1/16
2	4-1/8
3	5"
4	5-7/8
5	7"
6	8-5/16
7	10-2/8
8	15-1/2
9	17-3/8
10	18-11/16
11	19-13/16
12	20-11/16
13	21-1/2
14	21-9/16

*ONLY POINTS 8 THROUGH 14 WERE USED DURING TEST RUNS.

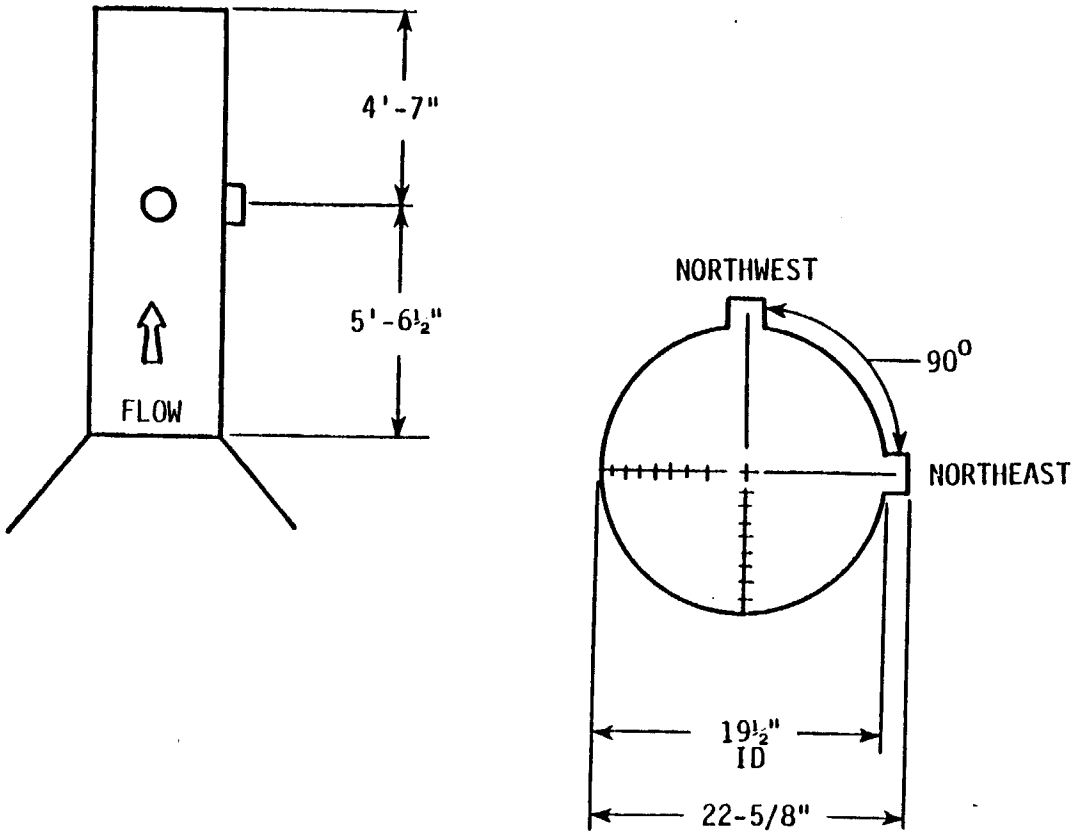


FIGURE 4-8: NEUTRALIZER NO. 1 SCRUBBER OUTLET SAMPLING LOCATION AT C F INDUSTRIES, INC., HARRISON, TENNESSEE

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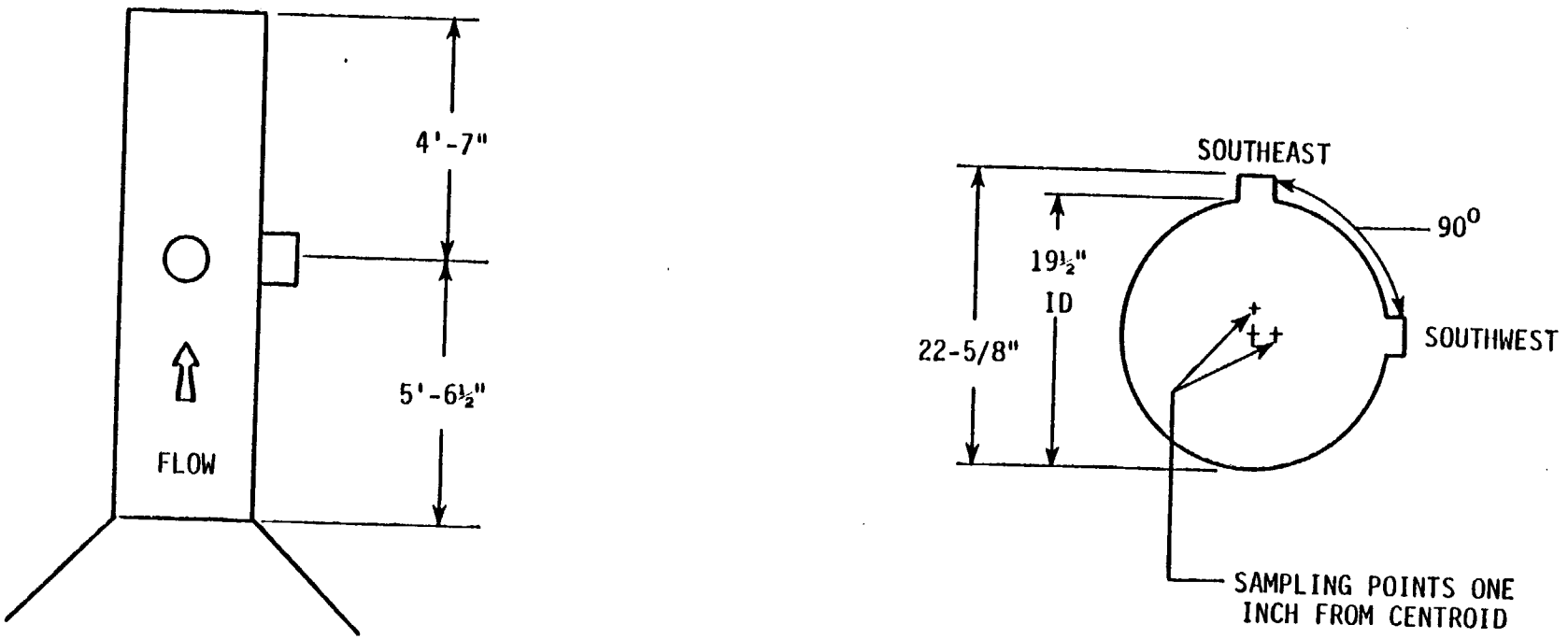

FIGURE 4-9: NEUTRALIZER NO. 2 SCRUBBER OUTLET SAMPLING LOCATION AT C F INDUSTRIES, INC., HARRISON, TENNESSEE

The inlet tap consisted of a stainless steel tube inserted through the special probe assembly into the center of the duct. The special probe assembly was inserted through the inlet sampling port. The outlet tap was a stainless steel tube inserted through the outlet sampling port into the center of the duct.

4.3.4 Scrubber Liquor Sampling

Scrubber liquor samples were taken from the Neutralizer No. 1 scrubber liquor inlet, downstream of the circulating pump discharge. The sampling location is shown in Figure 4-4.

4.4 Evaporators

4.4.1 Calandria Concentrator Outlet

The Calandria concentrator outlet sampling site was located in a 20-inch I.D. vertical stainless steel duct connecting the Calandria to the gaseous effluent duct from the Air-Swept Falling-Film Evaporator. Because of the extremely high moisture content in this duct, sampling was limited, with the use of an in-stack orifice, to one port and only one sampling point at the center of the duct. Figure 4-10 shows a schematic of this sampling location. The distances of this location from upstream and downstream flow disturbances were not determined because only one point was sampled.

4.4.2 Calandria and Air-Swept Falling-Film Evaporator Combined Outlet

The sampling site was located in a 19-5/8-inch I.D. vertical stainless steel duct venting gaseous emissions from both the Calandria concentrator and the ASFF separator. Two 2-7/8-inch pipe-flange sampling ports positioned 90°

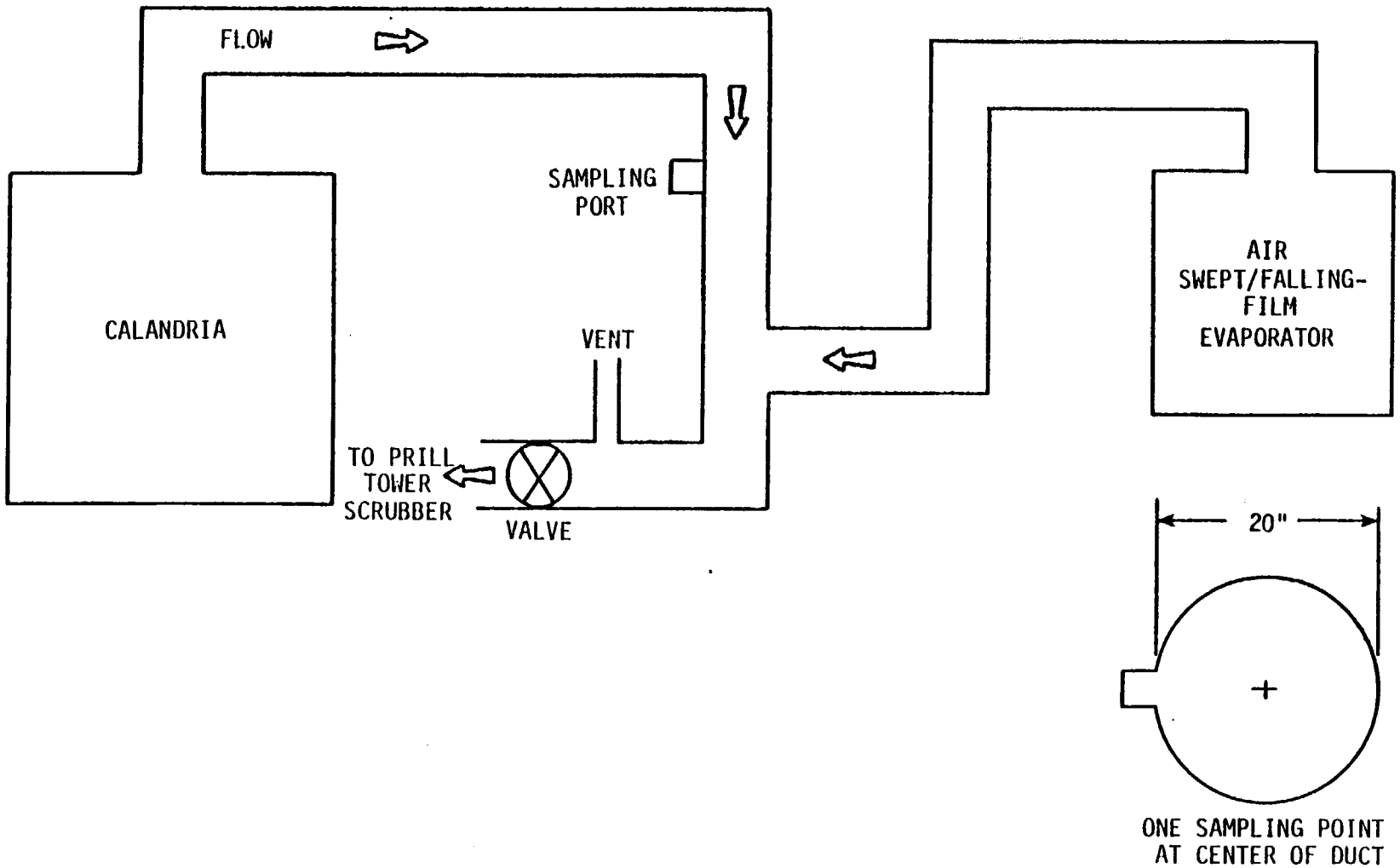

FIGURE 4-10: CALANDRIA EVAPORATOR SAMPLING LOCATION AT C F INDUSTRIES, INC., HARRISON, TENNESSEE

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apart were located 45-1/2-inches (2.3 duct diameters) downstream from the horizontal run of duct normally venting to the Koch scrubber, and 148-inches (7.5 duct diameters) upstream from the top of the stack.

Only the back half of each traverse axis could be used because of the physical limitations imposed by the in-stack orifice. Eight sampling points were chosen on each axis, for a total of 16 sampling points. Figure 4-11 shows a schematic of this sampling location.

4.5 Visible Emissions Observation Locations

The Prill Tower scrubber outlet stack plume was observed from the top of a holding tank 60 feet above the ground and 350 feet to the east of the stack. A large black warehouse and silo was used as a background. This observation position is shown in Figure 4-12.

The Prill Cooler scrubber outlet plumes were observed from a walkway 40 feet above the ground and 150 feet northeast of the stacks. The Prill Tower was used as background. This observation position is shown in Figure 4-13.

The combined plume from the two neutralizer scrubber stacks was observed from three different locations:

LOCATION	HEIGHT ABOVE GROUND	DISTANCE AND DIRECTION FROM NEUTRALIZER STACKS
A	0 feet	300 feet SSW
B	8 feet	75 feet NE
C	0 feet	150 feet W

The stack heights are 30 feet above ground level. Blue sky was used as a background from locations A and B; blue sky and/or the Prill Tower were used as a background from location C. Figure 4-14 shows these observer locations.

TRAVERSE POINT NUMBER	TRAVERSE POINT LOCATION FROM OUTSIDE OF NIPPLE (INCHES)
1	15-3/16
2	16-13/16
3	18-3/16
4	19-3/16
5	20
6	20-13/16
7	21-1/2
8	21-1/2

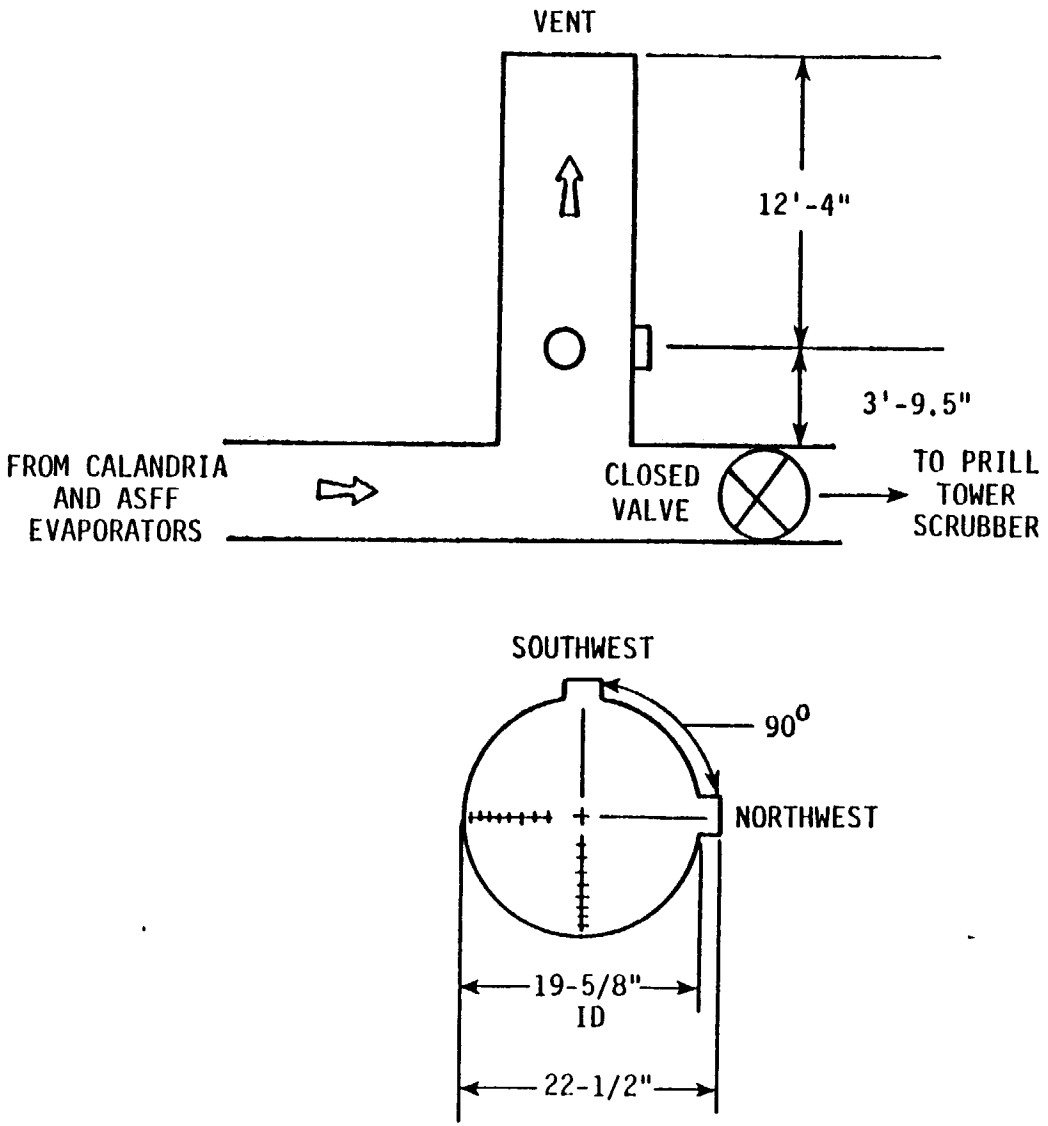

FIGURE 4-11: COMBINED CALANDRIA AND AIR-SWEPT FALLING-FILM EVAPORATOR SAMPLING LOCATION AT CF INDUSTRIES, INC., HARRISON, TENNESSEE

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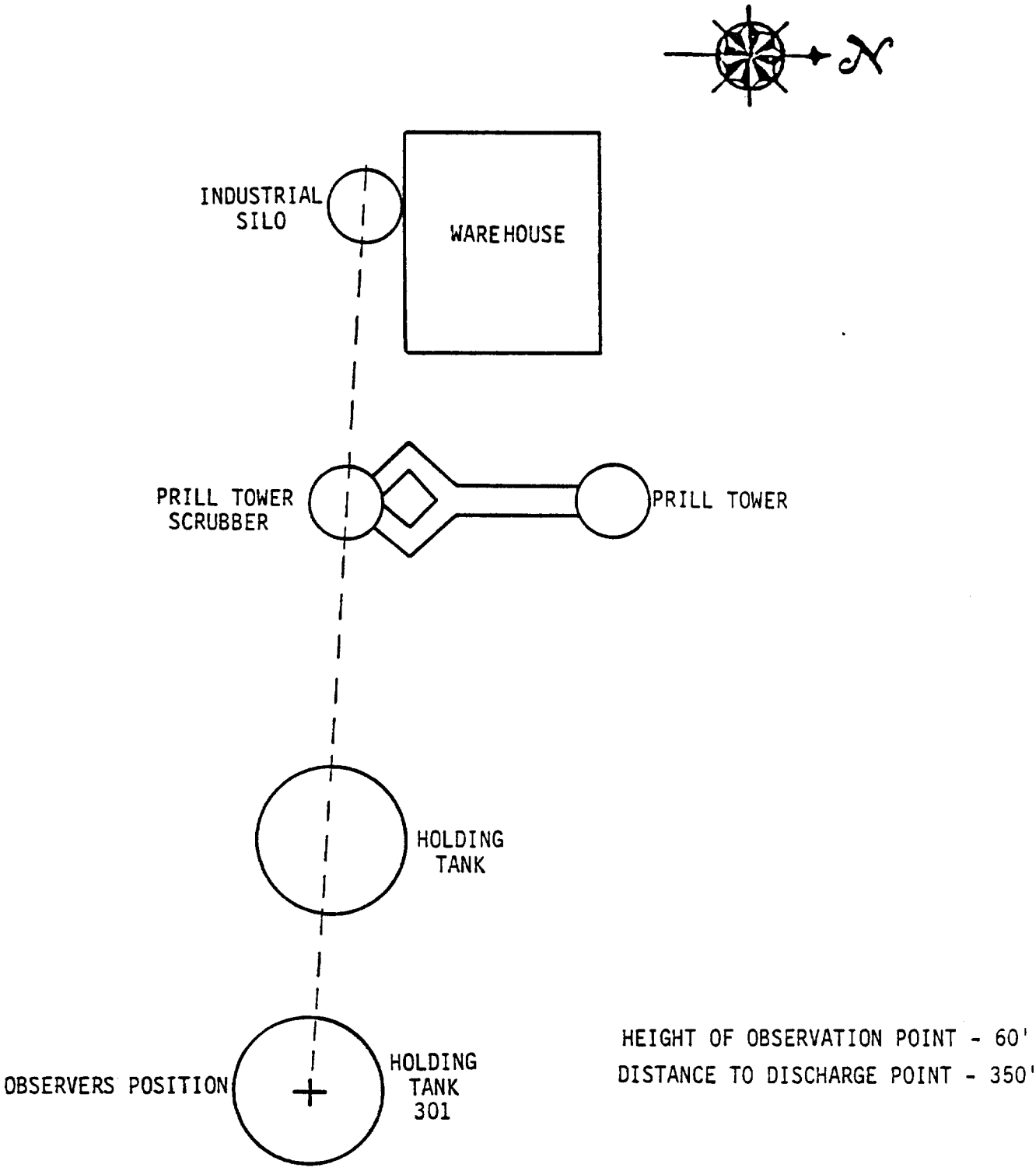

FIGURE 4-12: PRILL TOWER SCRUBBER VISIBLE EMISSIONS OBSERVATION LOCATION AT C F INDUSTRIES, INC., HARRISON, TENNESSEE

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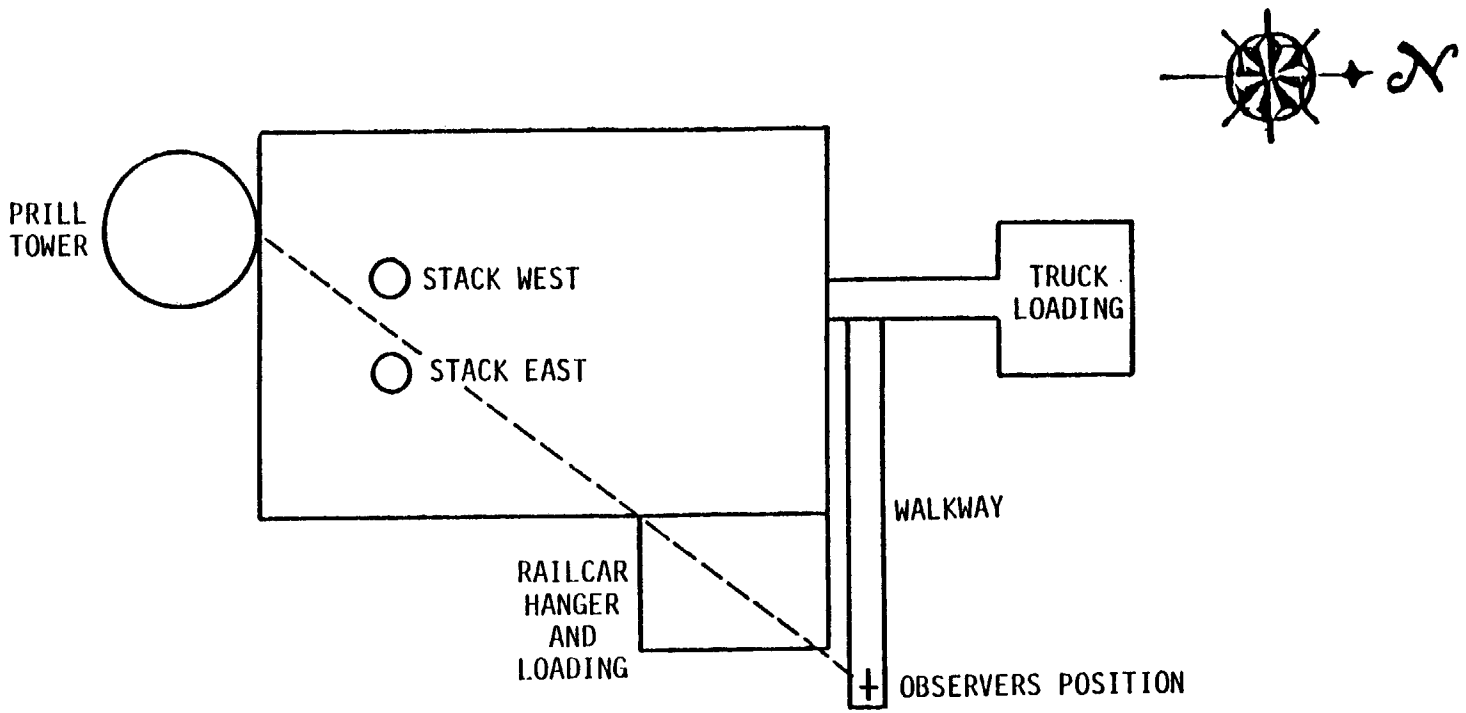

HEIGHT OF OBSERVATION POINT - 40'

DISTANCE TO DISCHARGE POINT - 150'

FIGURE 4-13: PRILL COOLER SCRUBBER VISIBLE EMISSIONS OBSERVATION LOCATION AT C F INDUSTRIES, INC., HARRISON, TENNESSEE

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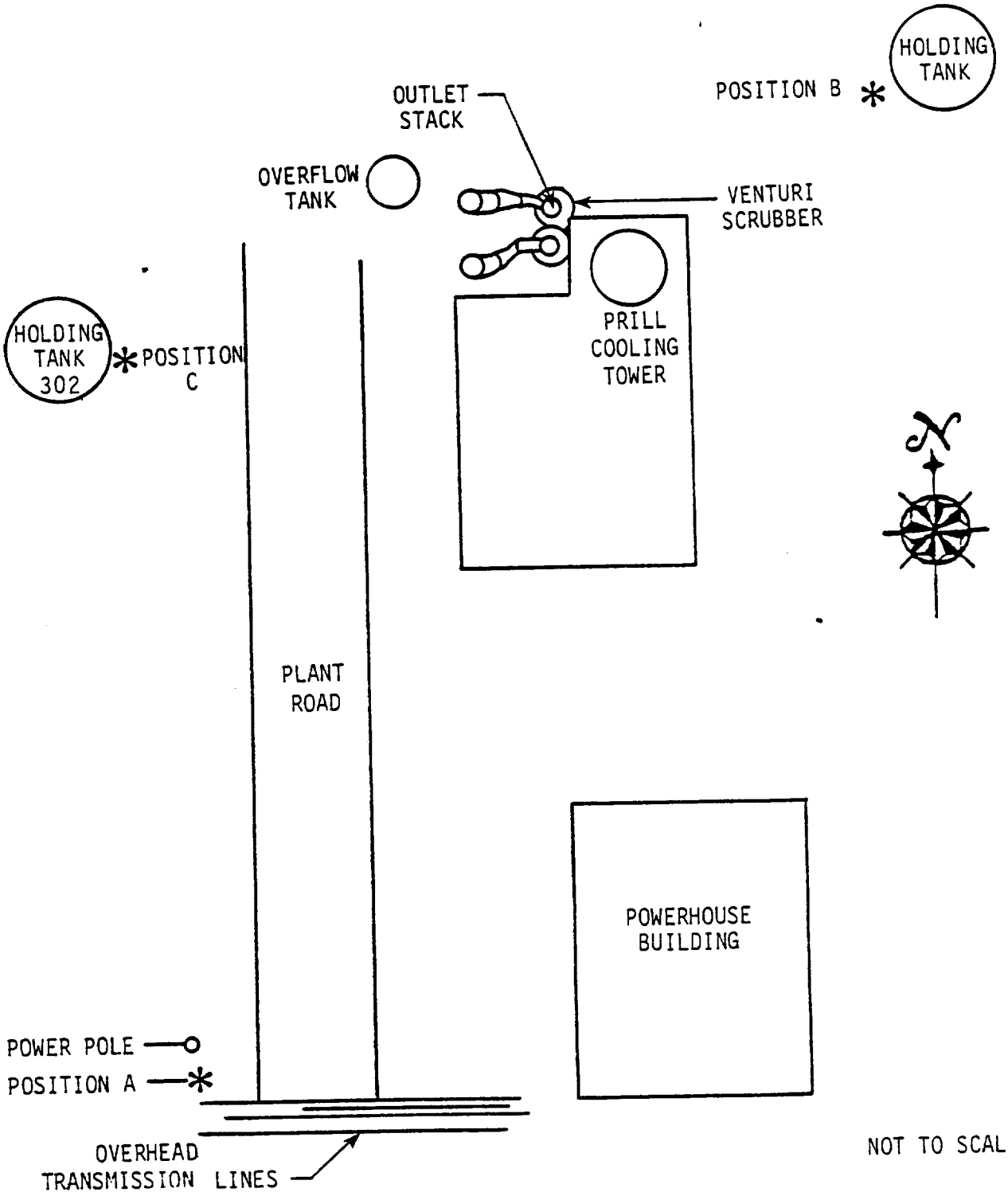

FIGURE 4-14: NEUTRALIZER SCRUBBER VISIBLE EMISSIONS OBSERVATION LOCATIONS AT C F INDUSTRIES, INC., HARRISON, TENNESSEE

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All visible emissions observer locations conformed to the EPA Reference Method 9 guidelines.

4.6 Product Sampling

Intermediate and final product samples were taken throughout the testing program directly from their associated processes. Sampled material included ammonium nitrate solution from the neutralizers and evaporators and solid prills from the Prill Tower and the Prill Cooler.

4.7 Ambient Air Measurements

Ambient temperature and relative humidity measurements were taken periodically during each emission test run in the immediate vicinity of the process unit being tested. Barometric pressure at each sampling location was measured with an aneroid barometer calibrated against a mercury barometer maintained by CFI.

During the Prill Tower emissions tests, temperature and relative humidity measurements were taken at the base of the Prill Tower. Measurements during the Prill Cooler testing were taken inside the cooler operation building. During the Calandria and ASFF evaporator testing, measurements were taken on the ground next to these process units.

5.0 SAMPLING AND ANALYSIS METHODS

This section presents general descriptions of sampling and analysis procedures employed during the emissions testing program conducted at the CF Industries, Inc., ammonium nitrate manufacturing facility in Harrison, Tennessee, during the weeks of May 7-11, 1979, and June 18-22, 1979. Details of sampling and analysis procedures are contained in the Appendices.

5.1 EPA Reference Methods Used in This Program

The following EPA Reference Methods were used during this emission testing program. These methods are taken from "Standards of Performance for New Stationary Sources, Appendix A," Federal Register, Volume 42, No. 160, Thrusday, August 18, 1977, pp 41755 ff.

- Method 1 - Sample and Velocity Traverses for Stationary Sources

  This method specifies the number and location of sampling points within a duct, taking into account duct size and shape and local flow disturbances. In addition, this method discusses the pitot-nulling technique used to establish the degree of cyclonic flow in a duct.

- Method 2 - Determination of Stack Gas Velocity and Volumetric Flowrate

  This method specifies the measurement of gas velocity and flowrate using a pitot tube, manometer and temperature sensor. The physical dimensions of the pitot tube and its spatial relationship to the temperature sensor and any sample probe are also specified.

- Method 3 - Gas Analysis for CO_2, O_2, Excess Air and Dry Molecular Weight

  This method describes the extraction of a grab or integrated gas sample from a stack and the analysis of that sample for CO_2 and O_2 with an Orsat analyzer.

- Method 4 - Determination of Moisture Content in Stack Gases

  This method describes the extraction of a gas sample from a stack and the removal and measurement of the moisture in that sample by condensation impingers. The assembly and operation of the required sampling train is specified.

- Method 5 - Determination of Particulate Emissions from Stationary Sources

  This method specifies the isokinetic sampling of particulate matter from a gas stream utilizing techniques introduced in the above four methods. Sample collection and recovery, sampling train cleaning and calibration and gas stream flowrate calculation procedures are specified.

- Method 9 - Visual Determination of the Opacity of Emissions from Stationary Sources

  This method describes how trained observers are to determine the opacity of emissions. The duration and frequency of observations, orientation of the observer with respect to the source, sun and background, methods of data recording and calculation, and qualifications of observers are specified.

Presently, the methods of cyclonic flow measurement and interpretation are largely in their formative stages. As noted in Section 2.3, cyclonic flow was observed and measured in the neutralizer scrubber outlet stacks. The pitot-nulling technique described in EPA Reference Method 1 was followed in determining the magnitude of one component of the flow angle. In this instance the actual sampling was performed without any adjustment for the flow angles. In situations where cyclonic flow angles are taken into account, the alignment approach (1) is generally used, as follows:

1. During particulate or velocity traverses, the probe top is rotated according to the measured flow angle at each traverse point so that the probe tip faces directly into the gas flow;
2. The sampling time at each traverse point is weighted according to the magnitude of the flow angle at that point;
3. The cosine of the flow angle is applied(2) to the velocity equations used to calculate flowrate.

(1) "Evaluation of Particulate Sampling Methods for Cyclonic Flow," Westlin, P.R., et al., OAQPS, ESED, EMB, TSS, August 2, 1979. See Appendix E.

(2) Source Sampling Reference Method, prepared by Entropy Environmentalists, Inc., for USEPA, November 1977. See Appendix E.

5.2 Ammonium Nitrate Sampling and Analysis

5.2.1 Sampling Methods

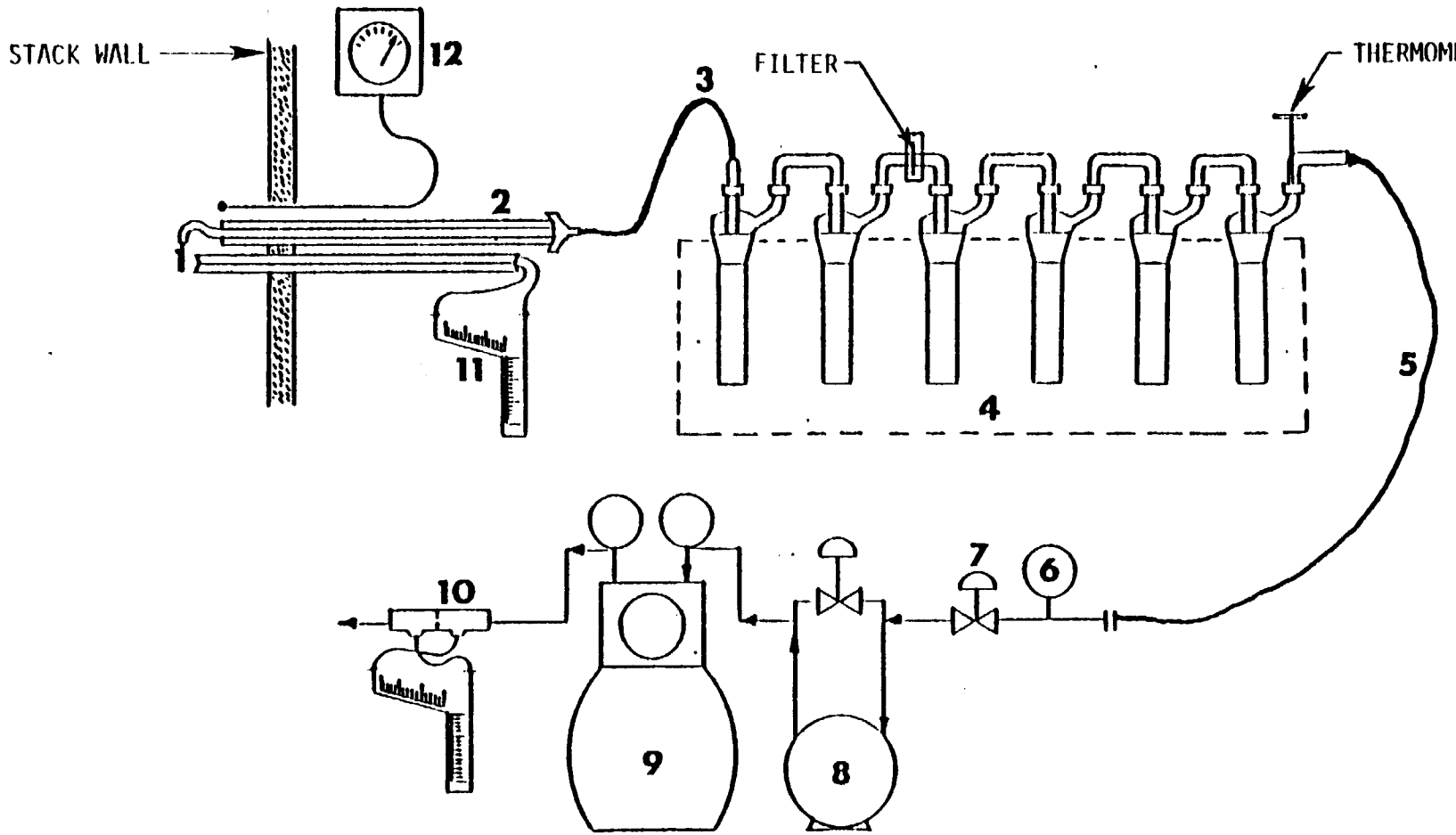
5.2.1.1 Prill Tower Scrubber and Prill Tower Cooler Scrubber

Ammonium nitrate in the Prill Tower scrubber and Prill Cooler scrubber inlet and outlet gas streams was sampled at points identified in accordance with the relationship of the sampling ports to upstream and downstream disturbances. The velocity of the duct gas was measured with S-type pitot tubes that were constructed, calibrated and used in accordance with EPA Method 2. Two traverse axes were utilized at each sampling location, and points along the complete length of each axis were sampled. Inlet and outlet sampling tests were run concurrently.

The sampling train used is shown in Figure 5-1, and is a modification of the standard EPA Reference Method 5 sampling train. The sampling train consists of a nozzle; probe, teflon line, six impingers, vaccum pump, dry gas meter, and an orifice flow meter. The nozzle is stainless steel and is of a buttonhook shape. It was connected to a 5/8" stainless steel glass lined probe. Following the probe, the gas stream passed through a 3/8" I.D. Teflon line into an ice bath/impinger system.

The first two impingers each contained 100 ml of deionized distilled water. Between the second and third impinger a glass fiber filter was positioned. This filter did not have to be tared bacause it was eventually added to the water contents of the first two impingers. The next two impingers were filled with IN H_2SO_4 (100 ml of each). The fifth impinger remained empty while the sixth was filled with 200 grams of indicating silca gel to remove any remaining moisture.

Leaving the last impinger, the sample gas stream flowed through flexible tubing, a vacuum gauge, needle valve, pump, and dry gas meter. A calibrated



LEGEND

1 - NOZZLE	7 - NEEDLE VALVE
2 - PROBE	8 - PUMP
3 - TEFLON LINE	9 - DRY GAS METER
4 - ICE BATH	10 - ORIFICE
5 - FLEXIBLE LINE	11 - PITOT TUBE & INCLINED MANOMETER
6 - VACUUM GAGE	12 - POTENTIOMETER

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

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orifice and inclined manometer completed the sampling train. The stack velocity pressure was measured with a pitot tube and inclined manometer. Stack temperature was monitored by a thermocouple attached to the probe and connected to a potentiometer. A nomograph was used to determine the orifice pressure drop required for any measured pitot velocity pressure and stack temperature in order to maintain isokinetic sampling conditions.

Test data recorded included test time, sampling duration at each traverse point, pitot pressure, stack temperature, meter volume, meter inlet-outlet temperature, and orifice pressure drop.

5.2.1.2 Neutralizer Scrubbers

The sampling train used at the Neutralizer scrubbers was similar to that used at the Prill Tower scrubber and Prill Cooler scrubber except that an in-stack orifice and eight impingers were used, and the glass fiber filter was positioned between the fourth and fifth impingers. The in-stack orifice was necessary because of the high moisture contents of the Neutralizer scrubber gas streams. With an in-stack orifice, the sampling rate can be measured at actual stack conditions prior to any moisture condensation.

The train configuration consisted of an in-stack orifice and nozzle assembly connected to a metal probe which was attached to eight impingers by a teflon line. The first three impingers were filled with deionized, distilled water (100 mls in each). The fourth impinger was empty. Between the fourth and fifth impingers, the glass fiber filter was positioned. The filter was not tared since it was eventually added to the water contents of the first four impingers. The fifth, sixth, and seventh impingers contained 10N H_2SO_4 solution (150 mls in each). The eighth impinger was filled with 200 grams of silica gel. The rest of the train was the same as that shown in Figure 5-1, but without the final orifice.

The inlet and outlet tests were run independently of each other. At the Neutralizer No. 1 scrubber inlet, access existed to only one sampling port. The relatively high pressure within the inlet duct (4 inches Hg) required the use of a special probe assembly and shut-off valve that would seal the port when inserted into the duct. A two-foot external extension was added to the inlet sampling port to facilitate use of this probe assembly.

Before each test run, the probe with in-stack orifice was inserted into the gas stream for about 15 minutes. This ensured that the orifice would be at stack temperature when sampling began. Orifice gas temperature was measured with an in-stream thermocouple located six inches from the orifice assembly. A typical in-stack orifice assembly is shown in Figure 5-2.

Some problems were experienced at the Neutralizer No. 1 scrubber inlet because of the high moisture content of the gas stream. As a result, complete sampling tests were performed only on Neutralizer No. 1 scrubber. Capillary tubing (0.1175 inch I.D.) connected the in-stack orifice pressure taps to regular pressure lines within the sealed probe housing. These capillary tubes frequently filled with water, thus interferring with monitoring of the sampling rate. Because of the high pressure in the gas stream, the plugged lines could not be easily blown out, so the following procedure was followed. An average orifice pressure drop was calculated to represent the average velocity pressure across the duct. This pressure drop was then set and left unchanged.

The outlet testing site on the Neutralizer No. 1 scrubber had two ports positioned 90 degrees apart. The static pressure was less than one inch of water at the outlet, therefore the valve and seal assembly used at the inlet was not needed. The outlet testing site had the same condensation problem occur with the in-stack orifice system. Since these outlet ports were not

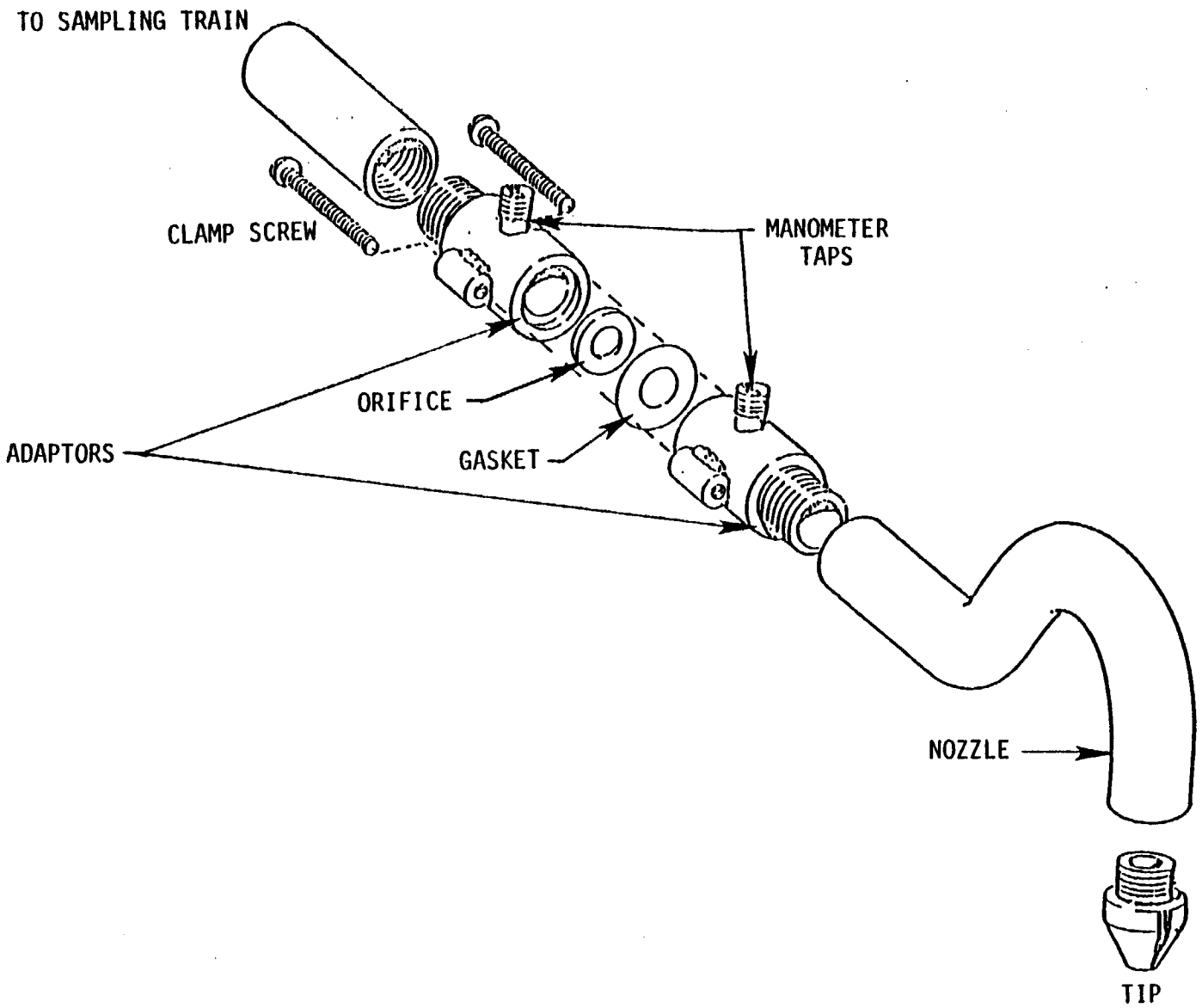

FIGURE 5-2: TYPICAL IN-STACK ORIFICE AND NOZZLE ASSEMBLY

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under pressure, the orifice pressure lines could be blown out with compressed air after each traverse point. Then the proper orifice pressure drop could be set at each traverse point to maintain isokinetic sampling. An excessive amount of water was collected in the impingers and they had to be emptied during port changes.

A special set of tests were performed on the Neutralizer No. 2 scrubber outlet, with two ports 90 degrees apart. Simultaneous sampling with two sampling trains (identical to those used on the No. 1 scrubber) was performed at one point on each traverse axis near the duct center. One train was operated at a sampling rate of approximately 200 percent isokinetic, and the other train was operated at approximately 50 percent isokinetic. The purpose of these special tests was to provide additional information for sampling neutralizer emissions.

5.2.1.3 Evaporators

The sampling trains at the Calandria vent and combined vent (Calandria and Air-Swept Falling-Film Evaporator) were identical to those used at the Neutralizer scrubbers.

Because of the small size of the Calandria vent and the extremely high moisture content of the gas stream, only one point (duct center) on one traverse axis was sampled. The extremely low dry gas flowrate through the sampling train resulted in an unusually high vacuum being drawn in the train. Extra care was required to minimize sampling train leaks and to make sure that the initial dead volume of gas in the train (normally insignificant) was discounted on the data sheets.

The test runs on the combined evaporator emissions were performed at two ports spaced 90 degrees apart. The much lower moisture content of this gas stream made sampling at several points along each traverse axis practical.

5.2.2 Sample Recovery and Preparation

o Prill Tower Scrubber and Prill Cooler Scrubber Samples

At the completion of each test run, the train was leak checked. Then the nozzle, probe, flexible teflon line, first two impingers, and their connecting glassware were rinsed three times with deionized, distilled water. Samples were put in glass containers with teflon-lined caps as follows:

Container #1 - contents of the nozzle, probe, flexible teflon line, first two impingers, filter holder, their connecting glassware, and the deionized distilled water wash of these articles along with the glass fiber filter.

Container #2 - contents of the third, fourth, and fifth impingers, their connecting glassware, and their 1N H_2SO_4 solution rinse.

Container #3 - silica gel from the sixth impinger.

The content of the first container was filtered using a tared Buchner funnel filter and a vacuum filtration setup in order to remove all traces of undissolved material. The funnel filter was then stored in a labelled petri dish and returned to the TRC chemical laboratory. The filtrate was divided into two equal portions with concentrated H_2SO_4 being added to one portion until its pH was six or less. To the second portion, 1 ml of 1M boric acid was added per 100 mls of sample.

o Neutralizer Scrubber and Evaporator Samples

A procedure similar to that described for the Prill Tower scrubber and Prill Cooler scrubber samples was followed. The contents of the sample containers were:

Container #1 - contents of the first 4 impingers, the filter and the distilled water wash of the nozzle, probe, teflon line, filter holder, and their connecting glassware.

Container #2 - contents of impingers 5, 6 and 7 and the 10N H_2SO_4 rinse of these impingers and their connecting glassware.

Container #3 - silica gal from impinger 8.

The water contents of Container No. 1 were filtered using a tared glass iber filter and a vacuum filtration setup to remove all traces of ndissolved material. This filtration was done with a vacuum flask, vacuum ump, and Buchner funnel. The filter was stored in a sealed petri dish and eturned to the TRC chemical laboratory. Then the filter from the sampling rain was added to the filtrate and allowed to dissolve out.

The filtrate was then divided into two portions: concentrated H_2SO_4 ras added to one portion until its pH was less than or equal to six; to the second portion 1 ml of 1M boric acid solution was added per 100 mls of sample.

5.2.3 Sample Analysis

o Prill Tower Scrubber and Prill Cooler Scrubber Samples

Only the boric acid treated portion of the water impinger samples was analyzed for ammonium nitrate (AN). The analysis was performed in the CFI laboratory within 48 hours of sampling, using the specific ion electrode (SIE) method.

An Orion Model 92-07 nitrate electrode was used to specifically measure the nitrate (NO_3) ion concentration in the sample. The amount of ammonium nitrate in the sample was computed by assuming that nitrate was the limiting species. Therefore, any dissociated nitrate ions detected in the sample solution originated as ammonium nitrate. The acidified portion of the water impinger samples and the acid impinger samples were not analyzed for AN because high concentrations of other ions interfere with the analysis.

No difficulties were encountered with the ammonium nitrate analyses of the Prill Tower scrubber and Prill Cooler scrubber samples.

o Neutralizer Scrubber and Evaporator Samples

Only the boric acid treated portion of the water impinger samples were analyzed for ammonium nitrate. The analyses were performed in exactly the same manner as described for the Prill Tower scrubber and Prill Cooler scrubber samples.

The interferring effects of high background ion concentrations were apparently observed in the Calandria samples, as discussed in Section 2.4. The Calandria gas stream contained a relatively high concentration of ammonia which, in aqueous solution as ammonium ion, may have positively interferred with the indicated ammonium nitrate (AN) concentrations. The result was calculated negative AN mass flowrates from the ASFF evaporator.

While this ammonia interference may explain the calculated negative ASFF ammonium nitrate mass flowrates, it also could have affected the neutralizer AN values. The ratios of ammonia concentration to AN concentration were as large or larger in the neutralizer samples as in the Calandria samples. Consequently, the neutralizer AN values presented in Section 2.0 may be somewhat greater than what actually exist. This interference was demonstrated in the analysis of audit samples (Appendix Q). The analysis of one audit sample, with an ammonia-to-nitrate concentration ratio of about 19, indicated a nitrate concentration 17% higher than the actual nitrate concentration.

It appears that the only sure way to circumvent such situations would be to remove or neutralize the interferring species. Because the degree of interference depends on the relative strength of the interferring ion concentration compared to nitrate ion concentrations, dilution of samples will not relieve the problem.

5.3 Ammonia Sampling and Analysis

5.3.1 Sampling, Sample Recovery and Sample Preservation

The same samples collected, recovered and preserved as described in Sections 5.2.1 and 5.2.2 were analyzed for ammonia as well as ammonia nitrate.

5.3.2 Sample Analysis

- Prill Tower Scrubber and Prill Cooler Scrubber

All acid impinger samples (Container #2) and the acidified portion of all water impinger samples were analyzed for ammonia by the specific ion electrode analysis method at the CFI laboratory within 48 hours of sampling. In addition, a portion of each of these outlet samples was brought to the TRC chemical laboratory and analyzed for ammonia by the Nessler method with preliminary distillation.[1] These Nessler analyses were done within 10 days of sampling.

An Orion Model 95-10 ammonia electrode was used for the SIE analysis. This method is extremely specific for ammonia and is not subject to the interferences that affect SIE ammonium nitrate analysis. To each sample was added enough 10M NaOH to bring the sample pH to 11 or greater, in accordance with the electrode manufacturer's procedures.

The Nessler analysis method is a colorimetric method subject to turbity interference from a variety of species. Delays in sample analysis may result in some species, like urea, breaking down or converting to ammonia and yielding falsely high ammonia concentrations. Alternatively, delays in sample analysis may allow dissolved ammonia to diffuse out of solution, yielding reduced ammonia concentrations.

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[1] Standard Methods of Water and Wastewater Analysis, 14th Edition, 1975, pp 412 ff.

A comparison of the SIE and Nessler data for the Prill Tower scrubber and Prill Cooler scrubber, as well as the Neutralizers and Evaporators, shows that some ammonia diffusion may have occured. Table 5-1 shows the average ammonia sample weight measured at each sampling location (averaged over the three test runs performed at each location). Over all tests at all locations, the ammonia weight indicated by the Nessler Method was 89% that indicated by the SIE Method. The Nessler analyses were performed within 10 days of the SIE analyses.

- o Neutralizer Scrubber and Evaporator Samples

These samples were analyzed in exactly the same was as described for the Prill Tower scrubber and Prill Cooler scrubber samples. All ammonia analyses were performed by both the SIE and Nessler methods.

The Neutralizer No. 1 (inlet and outlet) and Neutralizer No. 2 scrubber samples were also analyzed for CO_2 by CFI. This analysis was performed on the water impinger samples (Container #1) within 3 days of sampling using the Van Slyke method.

5.4 Magnesium Sampling and Analysis

5.4.1 Sampling, Sample Recovery and Sample Preparation

The same Prill Tower scrubber samples collected, recovered and prepared as described in Sections 5.2.1 and 5.2.2 were analyzed for magnesium as well as ammonium nitrate and ammonia. The one exception to the above sample preparation procedure was that a portion of the sample from the water impingers (Container #1) was set aside untreated (no boric acid solution or H_2SO_4 added) for magnesium analysis.

TABLE 5-1

COMPARISON OF AMMONIA ANALYSIS RESULTS FROM EMISSIONS TESTS
AT C F INDUSTRIES, INC.,
HARRISON, TENNESSEE

Sampling Location	Average Sample Weight*(mg) SIE[a]	Nessler[b]	Percent Ratio (Nessler/SIE) x 100
Prill Tower Scrubber Outlet	572	513	90
Prill Cooler Scrubber Outlet East	27	23	85
Prill Cooler Scrubber Outlet West	37	33	89
Neutralizer No. 1 Scrubber Inlet	48472	43584	90
Neutralizer No. 1 Scrubber Outlet	67608	64868	96
Neutralizer No. 2 Scrubber Outlet			
200% Isokinetic	18955	16570	87
50% Isokinetic	14171	12273	87
Calandria	7258	6640	91
Combined Calandria & ASFF	8437	7523	89
		Average	89

* Averaged of three test runs

a Specific Ion Electrode Analysis Method

b Nessler (with preliminary distillation) Analysis Method

5.4.2 Sample Analysis

The untreated portion of the water impinger sample and a portion of the acid impinger sample were brought to TRC and analyzed for total magnesium by atomic absorption (AA). An aliquot of sample was digested with a small amount of nitric acid in order to dissociate any bound magnesium. A small amount of this solution then was aspirated into the AA. These analyses were performed in the TRC laboratory within 10 days of sample collection.

5.5 Insoluble Particulate

The water impinger samples (collected as described in Section 5.2.1) were analyzed for insoluble particulate (undissolved solids) as follows. The contents of Container #1 were suction-filtered using a previously desiccated, tared glass fiber filter, Buchner funnel and vacuum system, as described in Section 5.2.2. The filter was then placed in a petri dish and brought to TRC. In the TRC laboratory, the filters were desiccated and weighed to a constant weight. This analysis took place within 10 days of sample collection.

5.6 Particle Size Distribution Tests

Particle sizing tests were conducted at the Prill Tower scrubber and Prill Cooler scrubber inlet sampling locations using a Sierra Model 226 multi-stage cascade impactor with a cyclone preseparator. Prior to testing the impactor was leak tested and the probe was placed in the gas stream for twenty minutes to allow it to reach equilibrium temperature in order to prevent condensation. Each test was thirty minutes in duration and was performed under isokinetic sampling conditions at a predetermined average gas velocity. The impactor was operated in its in-stack mode in accordance with the manufacturer's procedures.

The impactor was loaded before each test run with pre-weighed glass fiber collection substrates. Upon completion of a test run, the substrates were removed in a secluded, clean area and placed in petri dishes. The cyclone preseparator contents were brushed into a tared sample jar and sealed. These samples were brought to TRC and were weighed on an analytical balance to 0.1 mg in a constant humidity environment.

No meaningful data were obtained from the particle size distribution tests in the Prill Tower Scrubber inlet and Prill Cooler scrubber inlet because either too little particulate matter was collected or too much particulate matter was collected in the cyclone preseparator. The reasons for these erratic results could not be determined.

5.7 Integrated Gaseous Bag Sampling

An integrated gaseous bag sample from the Neutralizer No. 1 scrubber inlet was drawn directly from the gas stream during each of the ammonium nitrate particulate test runs. The sampling system consisted of a stainless steel tube, a flexible teflon line, three impingers in series (each containing concentrated sulfuric acid to absorb water) and a sample bag. The duct gas pressure was sufficient to fill the sample bag without a pump. This pressure also required that the stainless steel sampling tube be inserted into the duct through the special probe assembly designed to seal the sampling port.

The very low dry gas flow through the Calandria vent made it impractical to obtain an adequate sample of dry gas. For this reason, no samples were drawn at this location.

The bag samples were analyzed at the CF1 laboratory within one hour of sample collection. The samples were analyzed for CO_2 and O_2 using an EPA Method 3 Orsat analyzer.

5.8 Visible Emissions

Visible emissions observations were made on the Prill Tower scrubber outlet plume, the two Prill Cooler scrubber outlet plumes, and the combined plumes from the two Neutralizer scrubber outlets. Opacity readings were made simultaneously by certified TRC and CFI observers from locations chosen to conform to the requirements of EPA Reference Method 9.

The Prill Tower scrubber plume was monitored every fifteen seconds over a total observation period of about seven hours. Since the sky was overcast during most of this time, the blue-white plume was observed against a black industrial silo and warehouse.

The two Prill Cooler scrubber plumes (east and west) were monitored simulataneously at seven second intervals each, over a total observation period of about three hours. The Prill Tower was used as a background and no visible emissions were observed from the two stacks.

The two Neutralizer scrubber plumes mingled and were observed as one plume. The plume was monitored every fifteen seconds over a total observation period of about five hours. Three different observation locations were used, depending on the wind direction and lighting conditions. Blue sky or the Prill Tower were used as a background, and no visible emissions were observed.

5.9 Scrubber Pressure Drop Measurements

Pressure drop measurements across the Prill Tower scrubber, Prill Cooler scrubber and Neutralizer No. 1 scrubber were made with vertical U-tube water manometers connected to pressure taps at the scrubber inlets and outlets. Pressure drops were recorded every three to fifteen minutes during the Prill Tower scrubber and Prill Cooler scrubber test runs, and every six to thirty minutes during each of the neutralizer scrubber test runs.

5.10 Scrubber Liquor Sampling and Analysis

Half-liter aliquots of scrubber liquor were collected approximately every 30 minutes during the emission test runs at the Prill Tower scrubber, the Prill Cooler scrubber and the Neutralizer No. 1 scrubber. Scrubber liquor temperature was recorded at the time of collection, and the pH was measured in the CFI laboratory once the sample had reached room temperature.

The aliquots were then combined to form a single composite sample for each emission test run. The composite samples were suction-filtered through a tared glass fiber filter. The filtrate was then divided into two equal portions, and concentrated sulfuric acid was added to one portion to bring the pH to 6.0 or less. The second portion remained untreated.

The untreated portion was analyzed for nitrate by the specific ion electrode analysis method and (for the Prill Tower scrubber samples) for magnesium by atomic absorption. The acidified portion was analyzed for ammonia by both the specific ion electrode (SIE) and Nessler analysis methods. All these analyses were performed as described in Sections 5.2, 5.3 and 5.4. The Nessler ammonia concentrations averaged 88 percent of the SIE ammonia concentrations, presumably for the same reason noted in Section 5.3.2.

The filter was desiccated and then weighed to a constant weight in order to determine the undissolved solids content of the scrubber liquor.

5.11 Ambient Air Measurements

Ambient air temperature, relative humidity and barometric pressure measurements were made approximately every fifteen minutes during each emission test run. Measurements were made in the immediate vicinity of the process operation being tested. Relative humidity was determined from wet

bulb and dry bulb temperature measurements made with a Bendix psychron. Barometric pressure measurements were made with an aneroid barometer calibrated against a mercury barometer maintained at the CFI plant.

5.12 Process Sample Collection and Analysis

TRC personnel took samples of the solid ammonium nitrate product from the Prill Tower and Prill Cooler during the emission test runs at these process units. Bulk density and sieve analyses were performed on these samples at the CFI plant within two hours of sample collection.

The bulk density was determined using a tared graduated cylinder and a platform balance. The sample was passed through a riffle and then poured into the graduated cylinder until it overflowed. The sample was then leveled with the top of the cylinder, and the cylinder and contents were weighed.

The particle size of the product was estimated by means of a sieve analysis. A small amount (about 250 grams) of sample was weighted to the nearest 0.01 gram. This sample was then poured into the top sieve and then shaken through the stack of sieves. After shaking, each sieve was weighed to determine the amount of material retained by it.

Samples of the ammonium nitrate process solution were taken by CFI personnel from various loactions in the process. Chemical analyses were performed on these samples by CFI who requested that the analysis results remain confidential.