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A-79-55

II-D-42

Monsanto

AMMONIUM NITRATE
AP-42 Section 6.8
Reference Number

7

MONSANTO AGRICULTURAL PRODUCTS CO.
800 N. Lindbergh Boulevard
St. Louis, Missouri 63166
Phone: (314) 894-1000

December 4, 1978

Mr. Eric A. Noble
Industrial Studies Branch
Emission Standards and Engr. Div.
Research Triangle Park,
North Carolina 27711

Dear Eric,

Enclosed is our response to your AN emissions data survey. We appreciate your understanding of our inability to meet the requested completion date. You can readily see from the volume and detail of our response, coupled with the fact that much of the information required had to be researched in closed and stored files that a 30 day return time is just not sufficient to prepare a good faith response.

Pursuant to your telephone request, I have made a careful review and mark up to isolate only those pieces of data and information that Monsanto considers trade secret and confidential, instead of marking whole pages that contain the confidential information. In general, confidential treatment is requested only for costs and production capability and a few process control features relating to product quality.

We have included simplified non-confidential flow diagrams in the response, so we have stamped Monsanto's drawings 61271, 61272, 61273 as completely confidential. However, on drawings 61271 and 61273 the intent is not to restrict any contained information but simply to point out that we do not want our format reproduced and identified as submitted. If the simplified flow diagrams included in Section II of the process synopsis are insufficient for your purposes, EPA can freely expand those by transcription from 61271 and 61273.

However, drawing 61272 is so interspersed with descriptive process control schemes (unrelated to emission control) we request confidential handling of that document or any copies or reproductions thereof.

response for E-Donaco plant

Copy sent to EPA on 12/18/78

Eric A. Noble
December 4, 1978
Page 2

As I told you previously Monsanto is glad to cooperate with EPA on this project to develop realistic emission standards for Ammonium Nitrate, and we are certainly willing for EPA to have access to any data and information it needs to carry out that task. However, as discussed earlier the Ammonium Nitrate business is very competitive and cyclical. Monsanto has worked very diligently over many years to develop its position as a leading producer and market supplier with the top quality Ammonium Nitrate available anywhere. Information and data that are key factors in support of that position must be accorded Trade Secret and Confidential status.

I sincerely hope this blocking technique will allow you the needed flexibility to do some rewriting that allows most of the report to be freely circulated to other EPA sections and responsible contractor personnel. If you have any specific questions or problems give me a call at (314) 694-4956.

Sincerely,


D. E. Cayard
Manager, Manufacturing
Environmental Control

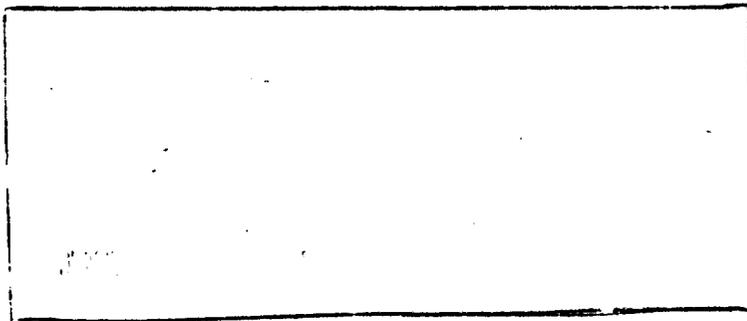
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Attachment

Rec'd
12/19/78
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INFORMATION BLOCKED IN THIS REPORT

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AND CONFIDENTIAL DATA.



*All Confidential
Information removed.
For full text see
Confidential Jacket*

SECTION 1.

GENERAL PROCESS SUMMARY

MONS. TO
EL DORADO PLANT

AMMONIUM NITRATE PRODUCTION INFORMATION

I. GENERAL

1. See

61271 Amm. Nitrate Concentration & Prilling
61272 A N Neutralizers
61273 Prill Tower Dust Collection System
No Number Ammonium Nitrate Prills Handling, Cooling
and Distribution
No Number Area III Remelt Concentration System

These drawings have been marked in red to show process reference number and emission control device letter.

2. The only ammonium nitrate product shipped from this plant is high density prills of a single specification. For a description of how ammonium nitrate is made see attached:

Standard Manufacturing Process for Ammonium Nitrate Solution 891.27 Sections I, II and III

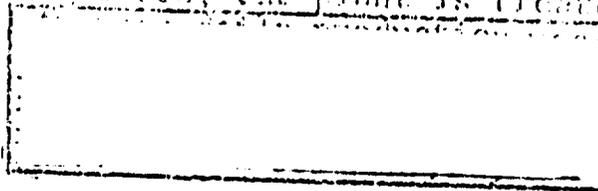
Ammonium Nitrate Production Operating Instructions Section I and II Process Description

The Product Specification
(5200-000-30-02-041)

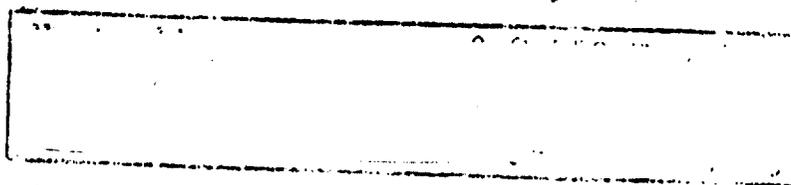
"A closely sized free flowing balls or prills of ammonium nitrate possessing a distinctive pearly lustre".

| | |
|----------------------|----------------------------|
| Moisture | 0.5% Max. |
| Additive (MgO basis) | 0.4 to 0.6% |
| pH (10% solution) | 5.5 Min. |
| Total N | 34% Min. |
| Loose Density | 60 lb/ft ³ Min. |
| Water Insoluble | 0.1% Max. |
| Particle Size | |
| On 6 mesh screen | 0% |
| Minus 6 plus 14 | 25.50% |
| Minus 6 plus 10 | 25.50% |
| Minus 6 plus 14 | 90% Min. |
| Through 20 | 0.7% Max. |
| Loading Temperature | 110 Deg. F. Max. |

two parallel neutralizers, one concentrator line, two spray nozzles and towers, two cooler lines, and one out loading line. Because of the single concentrator and out loading lines, the plant is treated as a one-line plant.



4. By major element, the designed capacity is:



Design capacity did not change from 1975 to 1977.

5. The number of days ammonium nitrate was produced at the plant were:

| | | |
|------|---|-----|
| 1975 | - | 261 |
| 1976 | - | 279 |
| 1977 | - | 271 |

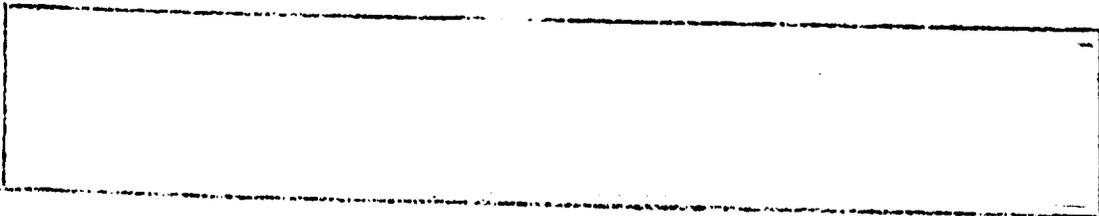
6. Production of ammonium nitrate was first begun in 1948. After that date, several modifications to the plant were made. The last of the production equipment described in this report was installed in 1967.
7. Flow rate of ammonium nitrate prills is measured on the out-loading conveyor with a nuclear belt scale system. The manufacturer of the scale system specifies an accuracy of $\pm 1\%$. Weights of railcars and bulk trucks as determined by platform scales are used to verify the belt scale's readings.

II. SOLUTION PRODUCTION

- A. 1. Neutralizer, process reference number 27.
The neutralizer is a Chemico design, conical bottom with a lower thermo-syphon tube for enhanced mixing of ammonia and nitric acid.

The thermo-syphon re-cycle rates are unknown. The operating temperature is 300 Deg. F at an internal pressure 1-2 psig. The pH of the solution is 3-4 and controlled by holding the overhead vapor pH at 7-9 depending on the condition of the feed injection orifices.

A. 2.



We are confused by the request for concentration of NH_3 and HNO_3 contained in the product stream. We operate by pH rather than by concentration of either feed ingredient which may be in excess.

3. The steam exhaust rate is the excess over that amount required to preheat the NH_3 feed at a given production rate. Previous calculations indicate that at a 700 T/D rate, 718,800 pounds of chemical steam are produced and 294,440 remain after feed preheat needs are extracted. All of this emission is controlled through mist eliminators 27-A-1, 27-A-2 and then to the atmosphere at a maximum rate of 27 pounds per hour of A R particulates. As an alternate the emission from 27-A-1 and 27-A-2 is further treated by passing through mist eliminators 74-B-1 and 74-D-2 to extract the superheat therefrom. The second case is the one most used.

At  851,200 pounds of chemical steam are produced and 462,980 pounds remain after feed preheat needs are extracted. The maximum ammonium nitrate particulates that may be emitted to the atmosphere remain at 27 pounds per hour.

The mist eliminators 27-A-1 and 27-A-2 have an ammonium nitrate removal efficiency of 97%.

4. The emission control technique is through the use of Monsanto Enviro-Chem MV mist eliminators 27-A-1, 27-A-2 in series most of the time with Enviro-Chem HE mist eliminators 74-D-1 and 74-D-2.
5. The operating parameter used to control the process is the pH (7-8) of the chemical steam vapor produced by the reaction. Lower pH results in HNO_3 vapor emission. Higher pH results in NH_3 emission. The vapor pH is continuously recorded.

B. Not Applicable.

III. CONCENTRATOR process reference 27,74.

1. Concentration is effected by three separate systems:

90-95% solution - low concentrator Whitleck Mfg. Co. evaporator, atmospheric, vertical tube, falling film with provision for later addition of a heated air blower. The design capacity is the evaporation of 9200 pounds/hr. water to produce 81,800 pounds/hr. of 95% ammonium nitrate. The temperature is controlled by throttling 275 psig saturated steam to produce 95% solution at 350 Deg. F.

95-99.5% solution - High concentrator Wenson, single effect vacuum, outside heating element, vertical, falling film evaporator operating at 28 mm Hg absolute pressure to evaporate 3100 pounds/hr. water to produce 73,300 lbs/hr. 99.5% solution.

The temperature is controlled by throttling 240 psig steam to produce a product at 370 Deg. F. The operating conditions have since been changed to throttle 275 psig steam to produce a product at 355 Deg. F.

50 - 90% remelt (reclaimed) solution
(Auxiliary concentrator)

This is an atmospheric pressure unit utilizing a flooded vertical tube heater (Ross, 565 sq. ft.) with pumped recirculation through a flash tank operating on 125 psig steam pressure. Estimated capacity is the evaporation of 5000 lbs/hr. water. It operates as needed to evaporate reclaimed A N solution.

2. The ammonium nitrate concentration produced in the neutralizers is 90% with occasional observations of concentrations in excess of 91%. The ammonia concentration in the overhead vapor varies from a few hundred to a few thousand parts per million.

The operating temperature is 300 Deg. F.

3. There is no off-gas feed to the neutralizers, only ammonia vapor and 56% nitric acid.

4. The additive used is $Mg(NO_3)_2$ in an amount of 0.4 to 0.6% of the solution (expressed as MgO).
5. There are no emissions from the high (95-99.5) concentrator since it operates under vacuum. Emissions from the auxiliary concentrator are uncontrolled and believed to be in an amount less than 1 lb/hr. A N and NH_3 . Emissions from the low concentrator (90-95%) are controlled with an Enviro-Chem HV mist eliminator. Ammonia emissions vary from 10 to 80 lbs/hr. A N emissions vary from 1.39 to 4.53 lbs/hr. The uncontrolled A N emissions have been reported at 60 lbs/hr.
6. Concentrator emission control techniques are:
 - 90-95 -Low Concentrator (A) - Enviro Chem Mist Eliminator
 - 95-99.5-High Concentrator (B) - Vacuum and Condensation
 - 50-90 -Aux. Concentrator (C) - Low Temperature
7. Vents accessible through sample ports.
8. The process of concentration is controlled by monitoring the product exit temperature and adjusting the heating steam supply pressure accordingly. Product exit temperature is recorded on all three concentrators. In addition, the vapor pressure and product flow are recorded on the low concentrator. It is unknown how changes in these parameters affect uncontrolled emissions.

IV. SOLIDS FORMATION

A. Prill Tower, process reference number 74.

1. There are two towers. Each tower is as follows:

| | Elev. |
|--|----------|
| Elevation of spray nozzle and top of tower | 227'-8" |
| Size of 15' x 20' cross section | 227'-8" |
| 15' x 20' continues down to | 199'-11" |
| Size transition down to | 198'-9" |
| Size 18'-7" x 23'-9 1/2" starts at | 198'-9" |
| Size 18'-7" x 23'-9 1/2" stops at | 128'-8" |
| Bottom cone starts at | 128'-8" |
| Bottom cone terminates with 3' square opening at | 110'-7" |
| 3 - 60" Dia. tower propellor fans all on one side. | |
| Centerline elevation | 204'-8" |

IV. SOLIDS FORMATION

A. 1. (Continued)

Tower outlet flow rates

Through tower exhaust fans 850,000 lbs/hr.
Plus tower dust collection duct
Air flow 225,000 lbs/hr.
Tower inlet temperature 70 Deg. F.

Heat removed from A N Btu/lb. A N prilled

Below TDGD 62
In TDGD 57
Total 119

Spray temperature 350 Deg. F.

A N Temp. bottom of tower

Expected in Design 221 Deg. F.
Guaranteed Max. 230 Deg. F.

Air outlet temperature can be calculated from above,
if humidity is known.

2.

Concentration 99.5%
Spray Temperature 350 Deg. F.

3. Spray device Nozzle

MANUFACTURER Sec. Eco-Kenner, La.

Method of Control -
a. reduction in pressure of
b. blanking off a portion of nozzle

4.

5. Solids pass through a bar grate onto a conveyor belt.
Large lumps are diverted by the bar grate to the remelt
ditch. The maximum solids temperature is 240 Deg. F.
The moisture content is 0.5%. The particle size dis-
tribution

Design Basis

<6 - 0, 6 to 8 - 12.5%, 8 to 10 - 22.9%, 10 to 12 - 36.5%,
12 to 14 - 24.8%, 14 to 16 - 2.0%, 16 to 20 - 1.0%, >20 - 0.3%

V. COOLER (one on each of 2 prilling tower units)

There are no dryers or predryers in the manufacturing train since A N melt usually meets moisture specifications when sprayed.

1. 8' 0" diameter by 52' 0" long rotary cooler manufactured by Standard Steel Corporation designed for 350 T/D A N cooled from 256 Deg. F to 100 Deg. F with 2760 lbs/hr. 50 Deg. F air warmed to an outlet temperature of 198 Deg. F.



2. Solids residence time is unknown.
3. The method of cooling is to blow refrigerated air from 2 - 75 ton Trane refrigeration units through each cooler.
4. Air inlet is saturated with moisture at 50 Deg. F. Air outlet at 200 Deg. F with the same absolute humidity.
5. Air inlet 50 Deg. F.
Air outlet 200 Deg. F.
Air flow rate 2670 #/hr.
6. Operating parameters monitored
 - a. TV monitor belt loading inlet and exit the cooler.
 - b. Pills exit cooler temperature. Recorded continuously.

We believe that tower bottom temperatures in excess of 240 Deg. F. will increase fuming on the belt exit the tower. We have done no work on this source of emission.

7. We don't know what it is.
8. The emission control technique is a tangential entry wet (Pease Anthony) spray scrubber.

VI. Not applicable.

VII. CONTROL EQUIPMENT

A. Wet Scrubber, control reference letter F

1. The scrubber is of the cyclonic spray type manufactured by Chemical Construction Corporation. Designation is Pease-Anthony. Equipment installed in 1949.
2. The scrubber is used to control emissions from the prill coolers as shown on process reference 74.
3. Information not available. See item 8 below for emissions from this control device.
4. This is a wetted gas scrubber. 30% liquid A. N. solution at about 100 Deg. F is sprayed against the air stream containing the A. N. dust. There are approximately 300 gpm against 20,000 cfm of air. Approximately 90% of the liquor is recycled. Scrubber drains to pump tank which overflows to reclaim system. No other level control.
5. Parameter monitored is exhaust blower amps.
6. Low motor amps indicate low liquid spray rates. The exact reduction in efficiency is not known.
7. The stack height is 53 feet, and the stack size is 4' 6" x 5' 4".
8. A copy of a test report is attached.

B - 1. Mist Eliminator, control reference letters A-1 and A-2.

1. High velocity mist eliminators with 7 elements manufactured by Monsanto Enviro-Chem Systems, Inc. and installed in 1973.
2. Controls emissions from neutralizers, process reference number 27.
3. Not applicable.
4. Gas stream characteristics:

| | |
|----------------|-----------------------------|
| Flow Rate: | 10,400 ACFM |
| Pressure Drop: | 3.5 in. H ₂ O |
| Temperature: | In-310 Deg. F; Out-275 Deg. |

4. Particulate Rate and Size Distribution (Mg/Min):

| | NH ₄ NO ₃ Based on NO ₃ | | NH ₄ NO ₃ Based on NH ₃ | |
|-----|---|-----------|---|-----------|
| | > 3 μ | < 3 μ | > 3 μ | < 3 μ |
| In | 782,080 | 1,036,480 | 706,160 | 2,262,000 |
| Out | 56,992 | 182,000 | 156,000 | 254,800 |

5. Surface Area - 47.7 Ft²
Spray Nozzle Flow Rate - 15 GPM
Spray Nozzle Pressure - 15 PSI
6. One spray nozzle, Spraying Systems Co. number 1" NH 11 W, is located in center of elements.
7. Two test reports are attached.
8. Stacks for these mist eliminators have a total length of 14 ft. Diameters are 20 in. for 7 ft. and 10 in. for 5 ft. with 2 ft. allowed for transition. Stacks also have branches that allow emissions to be discharged through B-3.

B - 2. Mist Eliminator, control reference letter B

1. High velocity mist eliminator with 7 elements manufactured by Monsanto Enviro-Chem Systems, Inc. and installed in 1973.
2. Controls emissions from low concentrator, process reference number 27
3. Not applicable
4. Gas stream characteristics:

Flow Rate: 5156 ACFM
Pressure Drop: 6.25 in. H₂O
Temperature: In-284 Deg. F; Out-210 Deg.

Particulate Rate and Size Distribution (Mg/Min):

| | NH ₄ NO ₃ Based on NO ₃ | | NH ₄ NO ₃ Based on NH ₃ | |
|-----|---|---------------------|---|---------------------|
| | > 3 μ | < 3 μ | > 3 μ | < 3 μ |
| In | 1.1x10 ⁷ | 1.0x10 ⁴ | 1.1x10 ⁷ | 3.4x10 ³ |
| Out | 7.2x10 ⁶ | 0 | 1.2x10 ⁶ | 0 |

5. Surface Area - 23.4 Ft²
 Spray Nozzle Flow Rate - .75 GPM
 Spray Nozzle Pressure - 35 PSI
6. Seven nozzles are located in the center of each element. Nozzles are Spraying Systems Company number 1/8" G4.3W.
7. Test reports referred to in B-1(7) includes test results for this device.
8. Two stacks are installed on this device. Both are 10 ft. in length and 12 in. in diameter.

B - 3. Mist Eliminator, process control reference letters D-1 and D-2

1. High energy mist eliminators with 42 elements for each tower manufactured by Monsanto Enviro-Chem Systems, Inc. and installed in 1978.
2. Mist eliminators controlling emissions from prilling towers, control reference number 2
3. See items IV-A-1 and IV-A-7 above for reference.

Percent Air Flow Through Cone - 21%
 Flow Rate - 225,000 Lbs/Hr.
 Temperature - Can be computed from IV-A-1.
 Cone Dimensions - 10 ft. long by 9 ft. diameter cylindrical section plus 36 ft. long by 9 ft. diameter inlet and 15 ft. diameter outlet truncated cone section.

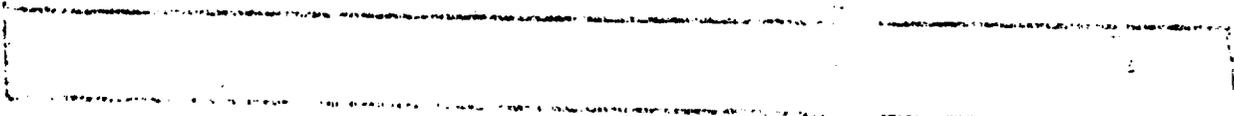
4. Characteristics of gas stream:
 Before - see attached W. R. Jones report and IV-A-7.
 After - See IV-A-7
5. Surface Area - 61.3 ft²/element
 Spray Nozzle Liquid Flow Rate - See item 6 below
 Spray Nozzle Liquid Pressure - See item 6 below
6. Spray nozzles are no longer used. Fog from neutral discharge is used to irrigate the elements. Initially 116 nozzles were used with approximately 5 GPM/nozzle.
7. Test report is attached.
8. No stack is installed.

- X. 1. Total energy consumption for ammonium nitrate production less pollution control equipment - 679,700 M Btu/yr. (based on 1977 actual energy use)
2. Energy consumption for each pollutant control system is:
- a) Pease-Anthony Scrubbers - 8826 M Btu/yr.
 - b) Prill Tower Brinks - 7502 M Btu/yr.
 - c) Neutralizer and Low Conc. Brinks - No energy usage

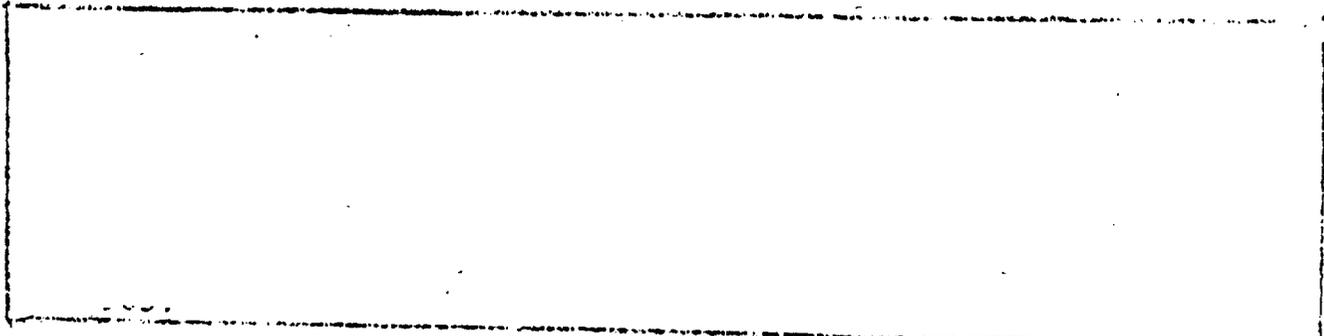
XI. Cost Information

XI. 4. Quantity of product in terms of ammonia recovered from the mist eliminators for the prilling towers has been calculated to be .005 Ton/Ton Product produced. Product recovery from the other mist eliminators and the wet scrubbers has not been calculated. Report number AD-S-15-20173 details product recovery from the other mist eliminators; however, the values shown in these limited tests are probably too high and are not representative of average values. Consequently, use of these numbers to calculate product recovery is not recommended.

The value of the product recovered has not been determined. The direct savings in terms of raw material costs are offset by energy costs required to reconcentrate the product recovered. These additional energy costs have not been calculated.



B. Not applicable



XII. No new ammonium nitrate facilities or air pollution control systems are planned or under construction at this time.

XIII. Plans for modification or reconstruction of the existing ammonium nitrate facility within the next 5 years do not exist at this time.

- | | | |
|----------------------|---|--------------------------------------|
| XIV. 1. Neutralizers | - | Visual inspection of internals |
| | | Replacement of spargers |
| | | Welding of vessel leaks |
| | | Standardization of pH electrodes |
| Acid Preheaters | - | Rotate tube bundle |
| Low Concentrator | - | Inspect Brink mist eliminator |
| 35 Tank | - | Standardize pH electrode |
| | | Wash out tank |
| 35 & 36 Pumps | - | Replace pump seals |
| 95 Filters | - | Clean filter elements when dirty |
| | | Replace filter elements when damaged |

- XIV. 1. High Concentrator - Clean distribution plate
Hydroblast tubes
Replace rupture disc
Tighten heads
Fix vacuum leaks
- Prill Valves & Spray Nozzles - Work on prill valves
Clean or replace spray nozzles
- Conveyors - Lubricate each month
Replace belt each year
Replace rollers when failed
Repair drive unit
- Prill Coolers - Weld cracks
Replace drive unit
- Screens - Recenter tires and trunnions
Replace screen twice yearly
Tighten screens each month
Repair/replace motor yearly
Adjust weights twice yearly
- Bucket Elevators - Replace buckets, 10-20/yr.
Replace entire belt every two years
- Car Puller - Replace broken cable as needed
- Barometric CF Pumps - Repair/replace pumps yearly
- Prill Tower Fans - Rewind armature and replace motor
2-3 times/yr.
- Brink Fans - Replace blades upon failure
Replace drive belts twice yearly
Balance rotor every two years
Replace motor upon failure
- MgO Silo - Replace bag filters twice yearly
Repair blowers/rotary valves when failed
- Supporting Systems,
Pumps & Piping - Something is worked on daily

2. Pump seals and filters on 95% A. N. Solutions
3. The prill nozzles are the only equipment that needs periodic replacement in the order of 4-6 times/yr. However, as noted in question A. 1, many parts of various equipment also needs replacing periodically.
4. Pump seal failures, filter/distributor clogging or failure, screen overflow, vacuum leaks, pump failures, and valve failures.
5. Costs, availability, and materials of construction.
6. Yes. Prills of a uniform size are demanded by our blasting agent customers, while farmers do not like granulated fertilizer since it forms clumps and does not flow evenly onto the fields.
7. Yes

- XIV. 8. Depends on process
- 9. Depends on process
- 10. Do not use any and do not have any knowledge of variability.
- 11. See Item 10.
- B. 1. Filter elements are checked every 6 months routinely and pH controller checked every Monday.
- 2. Do not have any material removed and not recycled.
- 3. Fan back pressure and pump pressure indicate proper efficiency.
- 4. Selection of the particular type of control devices was based on which ones provided the optimum control for the emitting equipment. Selection was also based on development and prototype testing.
- 5. Since we do not make urea, we do not have this information.

SECTI II

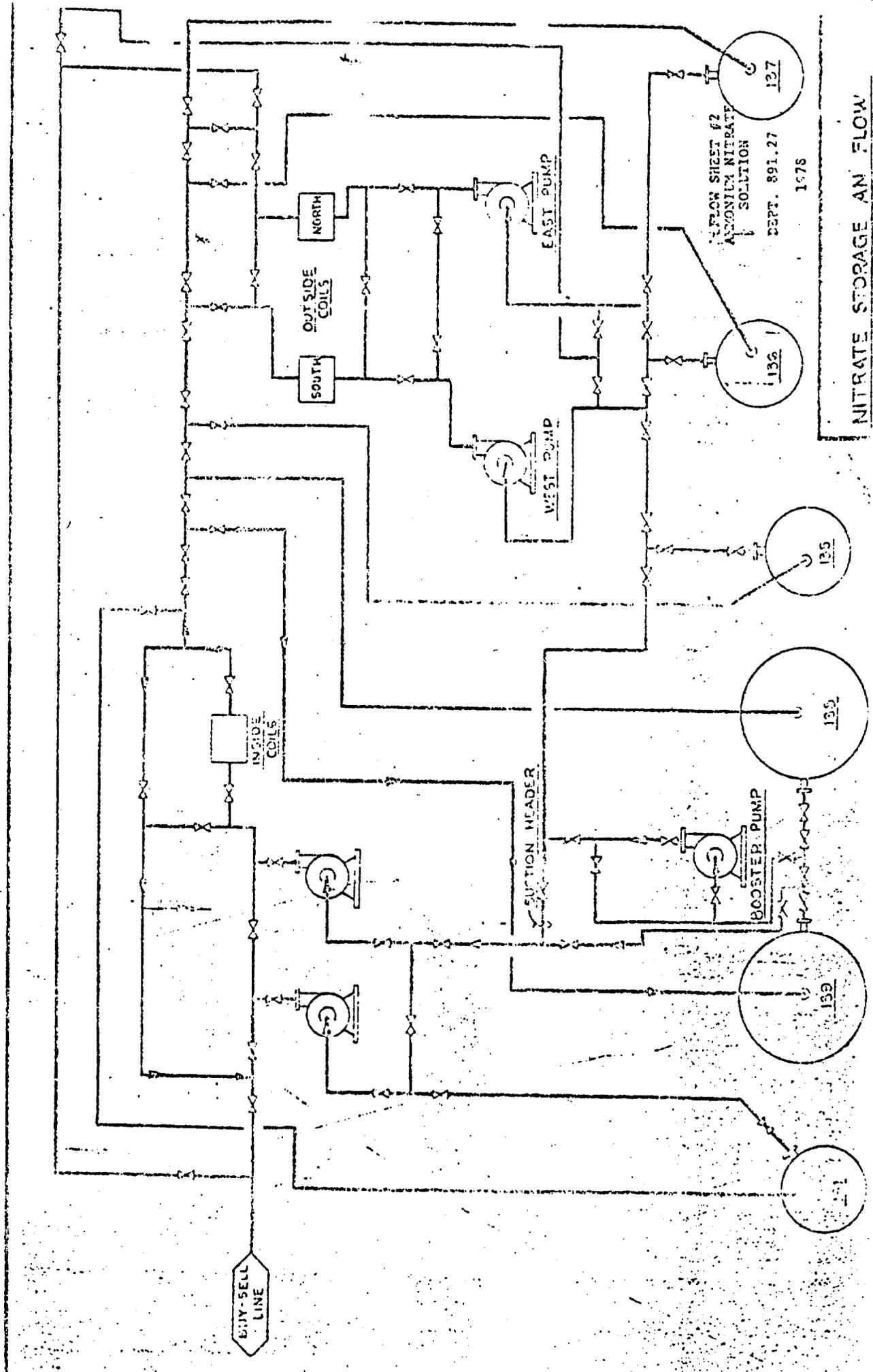
FLOW SHEETS

The flow sheets are process diagrams of the ammonium nitrate solution department showing the flow of fluids through neutralization, storage and low concentration. As indicated, there are two neutralizers sharing some common equipment. The neutralizers may be operated singly or simultaneously.

Materials of construction for piping, pumps and vessels are 300 series, low carbon stainless steel with these exceptions:

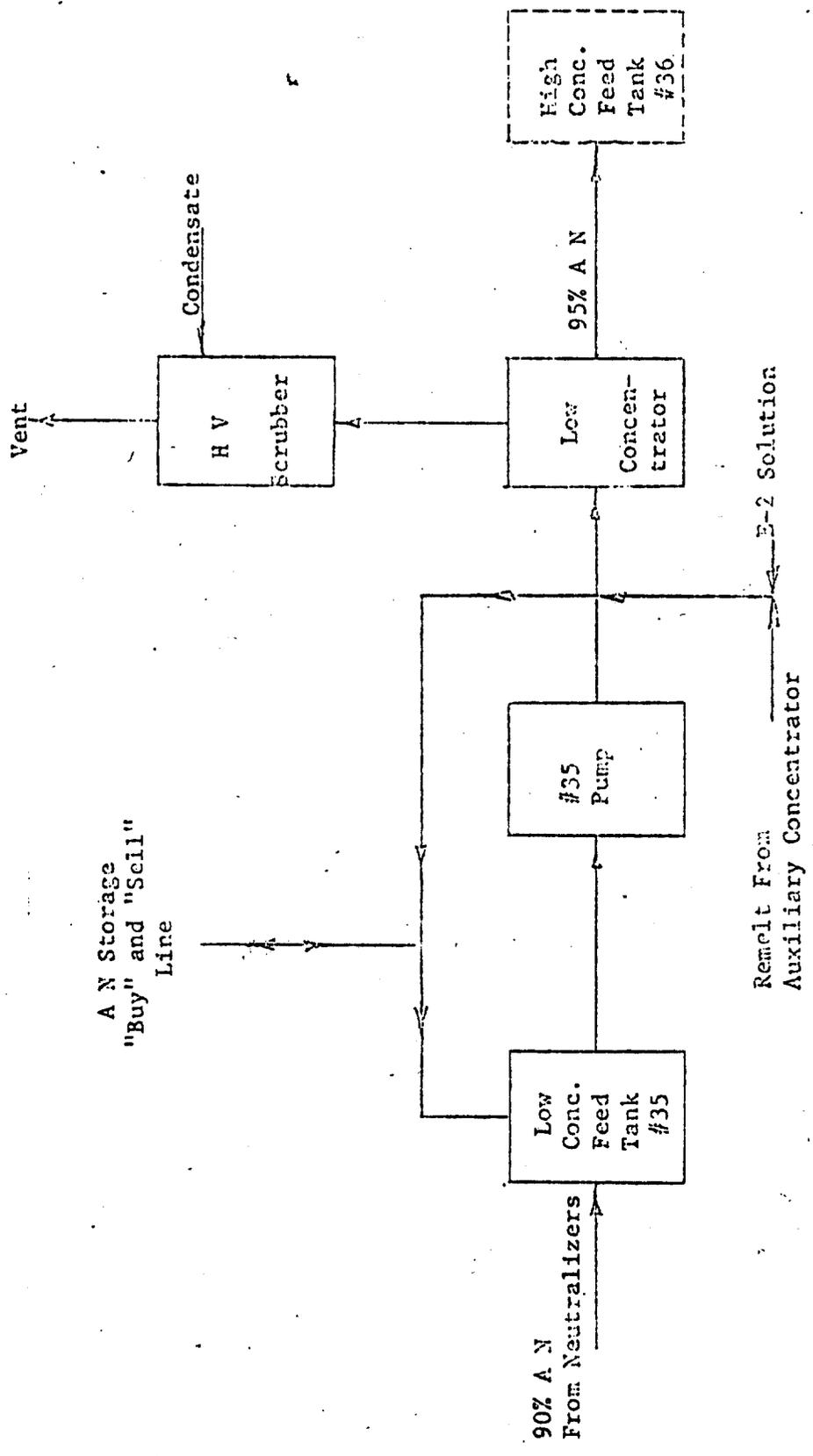
1. Ammonia piping, ammonia heater shells and ammonia flash tank are carbon steel.
2. Nitric Acid heater tubes and tubesheets, the neutralizer inner tubes and control valve internals in hot acid service are titanium.
3. The low concentrator feed tank (35) is Type 430 stainless steel.
4. A. N. storage tanks are 300 series stainless clad carbon steel.

Additional sheets or sketches showing vents, valves, drains, instruments, etc. are included elsewhere when needed for clarity.



FLOW SHEET #2
 AMMONIUM NITRATE
 SOLUTION
 SEPT. 891.27
 1978

NITRATE STORAGE AND FLOW

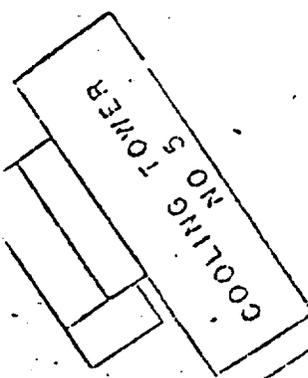


FLOW SHEET #3

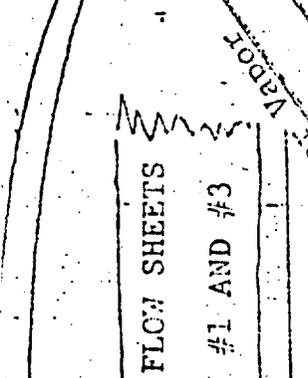
AMMONIUM NITRATE SOLUTION

DEPT. 891.27

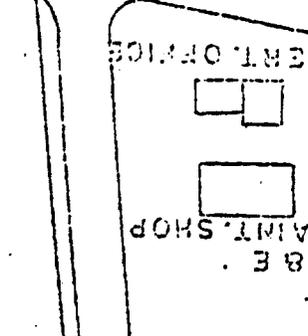
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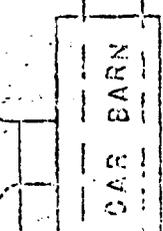
FIFTH



FLCM SHEETS #1 AND #3



18 E



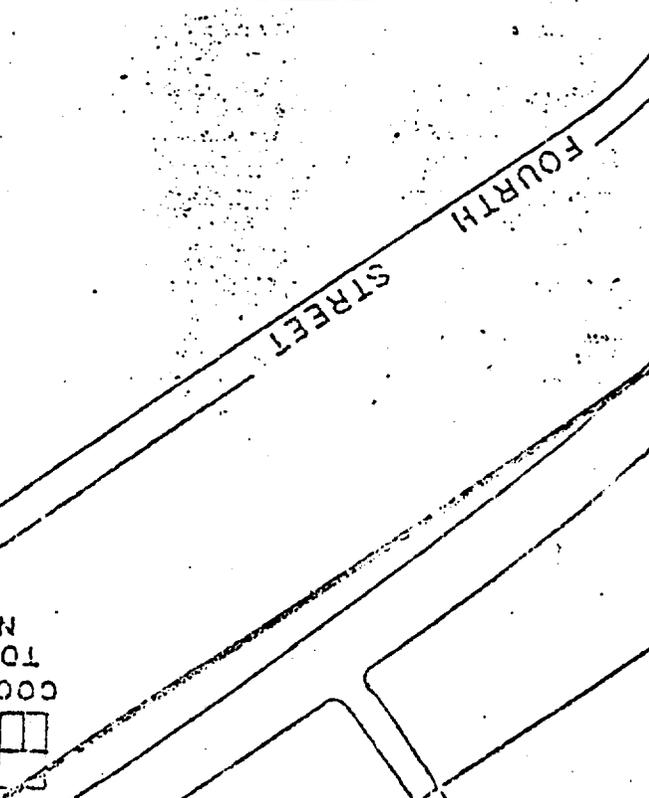
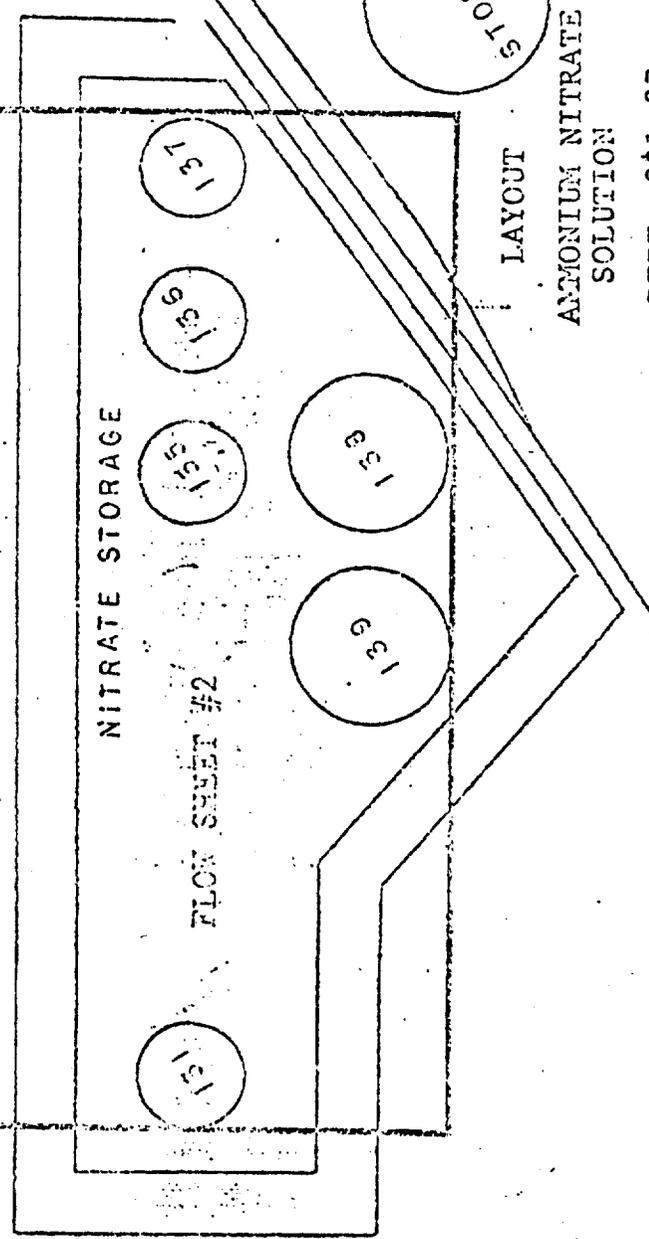
Ammonia Liquid and Sulfure Vapor



A "Buy" and "Sell" Gate



FOURTH STREET



STOPS

AMMONIUM NITRATE SOLUTION
DEPT. 891.27
978

SECTION III

PROCESS IN DETAILNITRIC ACID FEED SYSTEM

55.5% nitric acid from storage is pumped to the ammonium nitrate area through a 3" line. It then either passes through LCV-1727 or through the bypass valve into the nitric acid feed tank.

The nitric acid feed tank is equipped with a level controller that controls LCV-1727 and thus the flow rate of acid into the tank. An auxiliary sight glass is mounted on the tank both for calibration of the level controller and for visual observation of the level in case the controller becomes inoperative.

The nitric acid leaves the bottom of the tank and flows through a strainer and into the nitric acid feed pumps. A spare pump and strainer are provided.

The acid then flows through FE-1744, a magnetic flow meter, or through a bypass around the flow meter.

The acid enters the tube side of the nitric acid preheater, a removable U-tube heat exchanger, and is heated to 180-212 Deg. F, depending on the flow rate. A bypass around the exchanger is provided so that if it must be worked on, the plant can continue to operate.

Chemical steam enters the shell side of the exchanger, condenses and drains into a water seal leg that serves in place of a steam trap. The seal leg is designed to hold steam pressures up to 3 psig. An inert gas vent is provided that allows gases trapped in the exchanger to be bled to the atmosphere.

Both tube and shell sides of the exchangers are equipped with blow out or washout nozzles so that they may be cleaned in place or drained prior to repair work. The tube side of the exchanger is protected against liquid expansion (if both inlet and outlet valves are closed) by PCV-1753.

There are two acid preheaters, one for each neutralizer.

The acid flows to the neutralizers, with each neutralizer having its own acid flow control valve. Downstream from each control valve the acid enters a pipe loop that is designed to serve in place of a check valve and prevent ammonium nitrate solution from the neutralizers flowing back into the acid lines. Each loop is designed to withstand 5 psig steam pressure in the neutralizer.

After passing through the loop the acid enters a perforated tube sparger and is released into the neutralizer. The flow rate of acid is determined solely by the pH of the overhead vapor effluent from the neutralizers. The pH is normally kept slightly higher than neutral. Because of the fact that some ammonia escapes unreacted, the corresponding pH of the neutralizer liquid is purposefully low (about 2), it having been found that lower pH results in improved ammonia conversion.

AMMONIA EVAPORATION AND FEED SYSTEM

Liquid ammonia from storage is fed into the ammonia flash tank through a level control valve, LCV-1700, or through a bypass valve. When crossing the valve the ammonia pressure is reduced and part of the ammonia flashes.

The ammonia flash tank is equipped with a level controller, LIC-1700, that controls LCV-1700 and the flow of ammonia into the tank. An auxiliary sight glass is provided for calibration of the level controller and for visual observation in case of a malfunction of the controller.

The flash tank is close-coupled with the ammonia evaporator and the liquid ammonia flows out of the bottom of the flash tank and into the lower bonnet of the evaporator. As the ammonia rises in the tubes of the evaporator, it is partially vaporized and the mixed liquid-gas stream spews out of the evaporator and back into the side of the flash tank. The liquid droplets separate from the gas stream and fall back into the pool of circulating liquid ammonia, while the gas leaves the tank through a nozzle in the top.

The rate of ammonia evaporation is controlled by sensing the pressure in the gaseous ammonia line. Since the flow rate of ammonia into the neutralizer is held constant, the ammonia pressure will vary as the rate of ammonia evaporation varies.

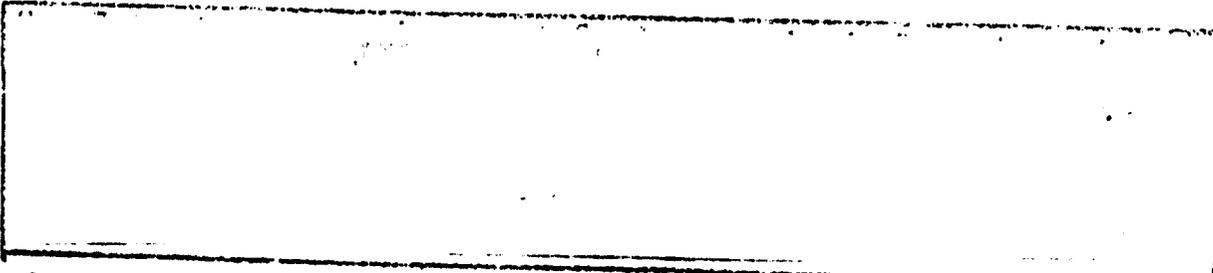
The evaporation rate is regulated by the amount of heat transferred to the liquid ammonia in the tubes of the evaporator by controlling the steam pressure and, thus, the temperature, and also by the condensate level.

Chemical steam enters the shell of the evaporator after passing through PCV-1701, where the steam pressure is reduced to 3-16 psia. The steam pressure controls the condensate level since the condensate drain dips into the sump tank and when the steam pressure is low enough it sucks condensate up from the sump tank and into the shell of the evaporator until the downward pressure exerted by the condensate is equal to the vacuum in the shell of the evaporator.

Since the evaporator is under vacuum a great deal of the time, a steam jet is provided to get rid of any noncondensibles that collect.

The gaseous ammonia from the flash tank passes into the shell side of the ammonia superheater where it is heated to 180-212 Deg. F, depending on the flow rate. The relief valve for the ammonia system, PCV-1752, is mounted on the shell of the superheater.

Chemical steam enters the tube side of the superheater, condenses and then drains out through a water leg seal that serves in place of a steam trap. The water leg is designed to hold steam pressures up to 3 psig. An inert gas vent is provided that allows gases trapped in the exchanger to be bled to the atmosphere.



Chemical steam is used in the preheater in a manner identical to its use in the ammonia superheater.

The preheated ammonia vapor flows to the ammonia header. Flow control valves regulate the flow of ammonia from the header to the neutralizers.

The ammonia to the #1 neutralizer goes through flow control valve FCV-1704, or the valve bypass, and then into a pipe loop that is designed to serve in place of a check valve and prevent ammonium nitrate solution from the neutralizer flowing back into the ammonia lines. The loop is designed to withstand 5 psig steam pressure in the neutralizer.

After leaving the loop the ammonia enters a manifold arrangement, splits into four streams and then enters the ammonia spargers.

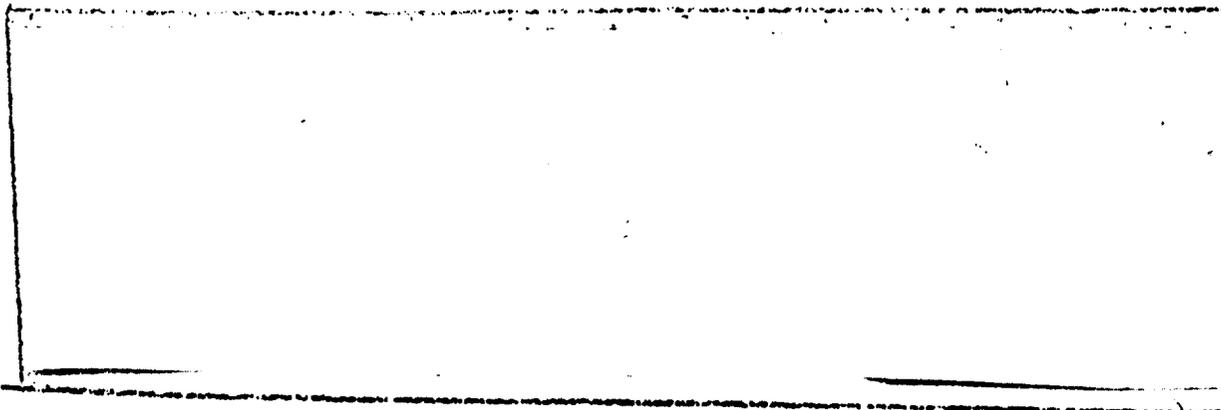
The ammonia to the #2 neutralizer goes through flow control valve FCV-1703, and then into #2 neutralizer, with piping arranged as it is to #1 neutralizer.

AMMONIA NEUTRALIZER AND SCRUBBER

The ammonia and nitric acid are introduced through spargers into the inner tube of the lower section of the neutralizer. The hot reaction mass rises in the tube until it hits conical baffle on the end and is deflected downward and outward. Enough heat is generated by the reaction so that as the mass rises the water in the nitric acid is vaporized and the solution boils. This boiling action cools the ammonium nitrate solution formed and it settles to the bottom of the neutralizer where the slightly lower pressure in the inner tube causes it to rise once again through the inner tube.

This natural thermosyphon circulation provides good mixing action, raising the conversion of the ammonia and providing a uniform acid content throughout the neutralizer.

The 90% ammonium nitrate solution leaves the neutralizer through an overflow nozzle and flows through a seal leg that prevents steam from blowing through.



The operating pressure of the chemical steam system is 1-3 psig and the pressure of the neutralizers only slightly higher. The neutralizers are protected by two rupture discs, one for pressure, set at 5 psig, and the other for vacuum, set at 1 psi below atmospheric pressure. There are two possibilities that can occur to cause vacuum.

1. The pressure controller is on manual operation and the chemical steam output is such that the steam vent valve is closed and the steam within the chemical system condenses.
2. The neutralizer is drained with both vapor and product valves shut.

The chemical steam produced in each neutralizer leaves the vessel through a nozzle in the top and enters the Enviro-Chem HV Scrubber. The steam passes through fiber packed panels where entrained particles of ammonium nitrate are trapped and returned by gravity to the neutralizer. A cup seal provides a path for the ammonium nitrate to return to the neutralizer without by-passing steam around the fiber packed panels. Condensate sprays are used to irrigate the scrubber panels when a pressure drop across them is observed.

The cleaned chemical steam from each neutralizer then enters the chemical steam system. Steam pressure is maintained by FCV-1 which vents excess steam to the prills BE Scrubbers. In the event of malfunction of FCV-1 vent valves PCV-1714 and PCV-1713 are set to open automatically. These vent valves also may be opened manually when it is desired to start up a neutralizer without back pressure on it.

At very low operating rates there is insufficient chemical steam pressure available to attain a continuous flow of the chemical steam condensate sample for pH monitoring and control. Under these circumstances a block valve on the chemical steam header is pinched back to limit chemical steam usage and allow the chemical steam header pressure to rise.

AMMONIUM NITRATE SOLUTION STORAGE

Ammonium nitrate solution in tank #35 in excess of the amount immediately needed for concentration and prilling is pumped through "sell" valve FCV-1764B and meter FT 1764B to the nitrate storage working tank. Conversely, any loss in tank #35 operating level is corrected by pumping from the storage working tank through "buy" valve FCV-1764A into tank #35. The operating mode is to maintain a high rate of flow through the "buy" and "sell" common line to storage to avoid freezing of the high melting point AN solution in the system. So this mode results in constant reversals of flow direction because of over selling and over buying.

two independent solution circulating systems each with pump, spare pump and solution heating coils. There is always at least one tank whose contents are being circulated through a heater. In so doing, the "buy" and "sell" line is kept under pressure, available for transfer to #35 tank or from #35 tank to the circulated tank. The circulated tank is referred to as the working tank.

The preferred working tank is either one of the two storage tanks that are insulated, tank #135 or tank #139. Tank #139, being larger, is usually chosen. The remaining tanks are "cold" storage tanks, that is, the AN solution is allowed to cool down and solidify and so remain until a need is anticipated.

To initiate the heating and melting of the contents of a cold tank a vertical channel must be opened in the solidified AN so that hot AN may be circulated through it and thus slowly melt the tank contents. For the purpose of initially opening a channel, there is a vertical steam heating or "gut" line running from a location near the top, fill line, to a location near the bottom, suction line. After sufficient time is allowed to initiate a channel, hot low pressure steam condensate is added to the suction line to thaw the nitrate plug from the tank suction line and initiate circulation. Movement of hot condensate in the line is correlated with a rise in temperature of the pipe surface. After heating of the entire length of the suction line is achieved, the circulation is commenced. As an aid to thawing the tank suction nozzle and block valve, condensate flash steam is directed on them through a hose from a nearby steam trap several hours in advance of attempting to circulate.

Tanks 138 and 139 being at a lower elevation than the circulating pumps require a suction booster pump to be used to remove the lower four feet of contents therefrom.

It can be seen by inspection of Flow Sheet #2 that there are many combinations of pumps and tanks that can be arranged for flexibility in circulating for heating and for "buying" and "selling".

LOW CONCENTRATION

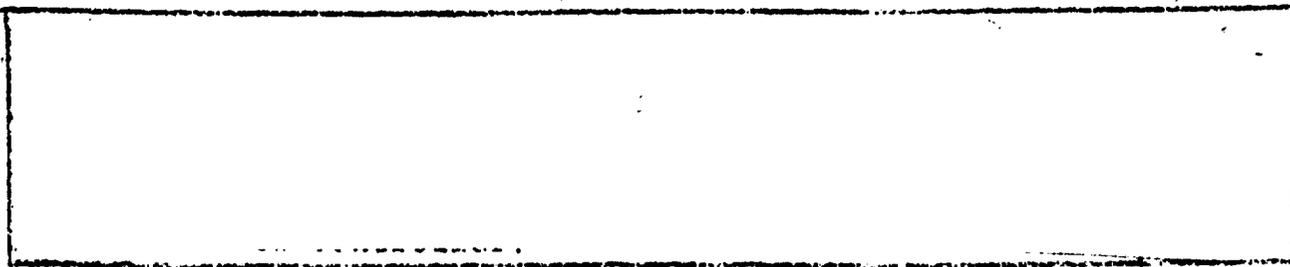
The 90% ammonium nitrate solution is pumped from tank 35 with the low concentration feed pump through FCV-1730 and into the low concentrator. Remelt solution from the auxiliary concentrator is fed into this same line to the concentrator.

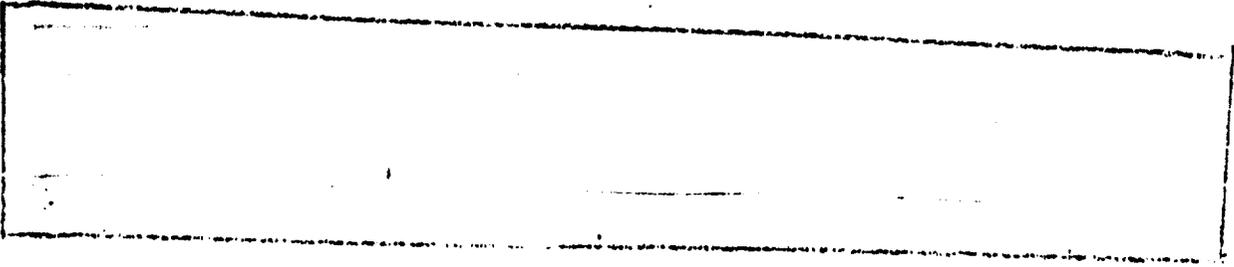
The solution is fed through a nozzle into the channel section on top of a vertical shell and tube exchanger, the low concentrator. It is distributed equally to each tube and flows down in a thin film counter current to a rising water vapor stream. The concentrated product flows by gravity to tank 36.

The water vapor leaves the top of the low concentrator and passes through a Monsanto Enviro-Chem HV Scrubber where entrained AN particles are trapped and returned by gravity. A cup seal provides a path for the ammonium nitrate to return to the low concentrator without by-passing steam around the fiber packed panels. Condensate sprays are used to irrigate the scrubber panels when a pressure drop across them is observed. Vapor from the scrubber then escapes to the atmosphere.

The temperature of the product stream is an indirect measurement of the concentration and by measuring this temperature and controlling the steam pressure in the concentrator heating element, with TICQA-1741, the product concentration may be controlled.

E-2 BLENDING





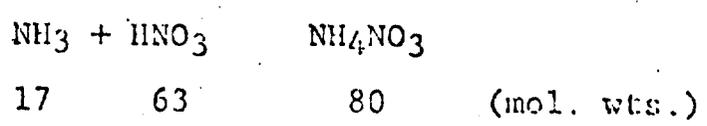
SECTION I

SYNOPSIS OF PROCESS

Ammonium nitrate is produced by the continuous neutralization of anhydrous ammonia with an aqueous solution of nitric acid. Both ammonia vapor and nitric acid are preheated before mixing in the reaction pressure vessel (neutralizer). This preheat plus the exothermic heat of reaction evaporates part of the water in the nitric acid to produce a ninety percent solution of ammonium nitrate. The water vapor is used as preheat steam.

The 90% solution is either immediately concentrated for prilling or stored as produced for later concentration and prilling.

The chemical reaction equation is:



The raw material requirements are:

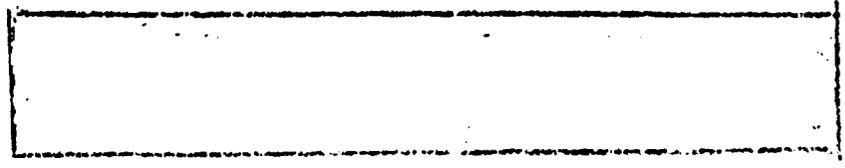
Ammonia

Theory 17/80 or .2125



Nitric Acid

Theory 63/80 or .7875



Two neutralizers are provided for the manufacturing of ammonium nitrate solution. The neutralizers are identical in operation and can be operated independently.

Steam produced in the neutralizers is recovered and used to pre-heat the nitric acid, off-gas ammonia streams from No. 3 Acid and ammonia storage, and evaporate and superheat the liquid ammonia. This preheating of the feed streams to the neutralizers gives a neutralizer product of 90% ammonium nitrate and greatly reduces the amount of high pressure steam required for concentration.

Liquid ammonia from storage is fed into the ammonia flash tank at a rate controlled by the liquid level controller on the tank. By natural thermosyphon action the ammonia is circulated through the ammonia evaporator and is partially vaporized with both liquid and gaseous ammonia returned to the flash tank. The liquid returns to the circulating stream and the gas leaves through a nozzle in the top. The gaseous ammonia then flows through the ammonia superheater where it is heated to 180-212°F by chemical steam. The ammonia is then fed into either or both neutralizers at the desired flow rate using a flow control system.

The rate of ammonia evaporation is controlled by the chemical steam pressure on the shell side of the evaporator. The steam pressure affects three controlling variables:

1. The degree of superheat and, thus, the heat transfer coefficient.
2. The condensing film temperature or the effective ΔT .
3. The condensate level or the effective heat transfer area.

Nitric acid is pumped into the nitric acid feed tank at a rate determined by a level controller on the tank. From there it feeds by gravity to the nitric acid feed pump and is pumped through the nitric acid preheater where it is heated to 200-210°F by chemical steam.

The hot ammonia and nitric acid enter the neutralizers through loops that serve in place of check valves and are fed in through spargers into a long vertical tube suspended in the neutralizers. The reacting mass rises in the tube until reaching the top where it is deflected downward into an annular space between the tube and the wall of the neutralizer until it reaches bottom and again flows upward through the tube. This thermosyphon circulation provides good mixing and aids in the neutralization of the ammonia. The heat of reaction provides enough energy to boil and concentrate the solution to approximately 90%.

The steam produced in the neutralizers goes through a Brink mist eliminator where most of the nitrate entrainment is removed. The cleaned chemical steam then enters the chemical steam system.

The ammonium nitrate solution leaves the neutralizer through an overflow nozzle and flows into seal tank 35.

The mixed solutions fall onto a liquid distributor plate and then into the tubes of the heating element section. The concentrated nitrate solution collects in the bottom of the concentrator and flows into seal tank 36.

The concentrated solution in tank 36 is pumped to the high concentrator and concentrated to a 99+% concentration.

The nitrate solution is drilled through a cone suspended in the tower. A portion of the tower air flow is pulled through the cone capturing most of the nitrate dust emissions; this air enters a scrubber where Brink Mist Eliminators trap the nitrate particles. The nitrate particles collected on the filters fall into the scrubber sump. Eventually the solution in the sump is concentrated by the evaporator action of the scrubber and enters the remelt concentration system. The neutralizer stacks can be put into the scrubber to recover that nitrate which gets past the neutralizer brinks. A pH control system is provided to maintain the scrubber sump slightly on the acid side when the neutralizers are venting into the scrubber. This prevents damage to the brink elements due to attack by an ammonia atmosphere.

SECTION 2

DETAILED PROCESS DESCRIPTION AND OPERATION

NITRIC ACID FEED SYSTEM

Fifty-six percent nitric acid from storage is pumped to the ammonium nitrate area through a 3" line. It then either passes through LCV-1727 or through the bypass valve into the nitric acid feed tank.

The nitric acid feed tank is equipped with a level controller that controls LCV-1727 and thus the flow rate of acid into the tank. An auxiliary sight glass is mounted on the tank both for calibration of the level controller and for visual observation of the level in case the controller becomes inoperative.

The nitric acid leaves the bottom of the tank and flows through a strainer and into the nitric acid feed pump. A spare pump and strainer are provided.

The acid then flows through FM-1744, a magnetic flow meter, or through a bypass around the flow meter.

The acid enters the tube side of the nitric acid preheater, a removable U-tube heat exchanger, and is heated to 180-212 °F., depending on the flow rate. A bypass around the exchanger is provided so that if it must be worked on, the plant can continue to operate.

Chemical steam enters the shell side of the exchanger, condenses and drains into a condensate tank where it is later used as make-up to the No. 8 cooling tower cold pond. An inert gas vent is provided that allows gases trapped in the exchanger to be bled to the atmosphere.

Both tube and shell sides of the exchangers are equipped with blow-out or washout nozzles so that they may be cleaned in place or drained prior to repair work. The shell side of the exchanger is protected against liquid expansion if both inlet and outlet valves are closed by PCV-1753.

The acid flows to each neutralizer through two flow control valves piped in parallel. A 2" valve is set manually at near the desired neutralizer rate.

Downstream from the control valves the acid enters a pipe loop that is designed to serve in place of a check valve and prevent ammonium nitrate solution in the neutralizer from flowing back into the acid line. Each loop is designed to withstand 5 psig steam pressure in the neutralizer. After passing through the pipe loop the acid enters a perforated tube sparger and is released into the neutralizer.

AMMONIA EVAPORATION AND FEED SYSTEM

Liquid ammonia from storage is fed into the ammonia flash tank through a level control valve, LCV-1700, or through a bypass valve. When crossing the valve the ammonia pressure is reduced and part of the ammonia flashes.

The ammonia flash tank is equipped with a level controller, LIC-1700, that controls LCV-1700 and the flow of ammonia into the tank. An auxiliary sight glass is provided for calibration of the level controller and for visual observation in case of a malfunction of the controller.

The flash tank is close-coupled with the ammonia evaporator and the liquid ammonia flows out of the bottom of the flash tank and into the lower bonnet of the evaporator. As the ammonia rises in the tubes of the evaporator, it is partially vaporized and the mixed liquid-gas stream spews out of the evaporator and back into the side of the flash tank. The liquid droplets separate from the gas stream and fall back into the pool of circulating liquid ammonia, while the gas leaves the tank through a nozzle in the top.

The rate of ammonia evaporation is controlled by sensing the pressure in the gaseous ammonia line. Since the flow rate of ammonia into the neutralizer is held constant, the ammonia pressure will vary as the rate of ammonia evaporation varies.

The evaporation rate is regulated by the amount of heat transferred to the liquid ammonia in the tubes of the evaporator by controlling the steam pressure and, thus, the temperature, and also by the condensate level.

Chemical steam enters the shell of the evaporator after passing through PCV-1701, where the steam pressure is reduced to 3-16 psia. The steam pressure controls the condensate level since the condensate drain dips into the sump tank and when the steam pressure is low enough it sucks condensate up from the sump tank and into the shell of the evaporator until the downward pressure exerted by the condensate is equal to the vacuum in the shell of the evaporator.

Since the evaporator is under vacuum a great deal of the time, a steam jet is provided to get rid of any non-condensables that collect.

The gaseous ammonia from the flash tank passes into the shell side of the ammonia superheater where it is heated to 180-212 °F., depending on the flow rate. The relief valve for the ammonia system, PCV-1752, is mounted on the shell of the superheater.

Chemical steam enters the tube side of the superheater, condenses and then drains out through a water leg seal that serves in place of a steam trap. The water leg is designed

AMMONIA EVAPORATION AND FEED SYSTEM, Continued

to hold steam pressures up to 7 psig. An inert gas vent is provided that allows gases trapped in the exchanger to be bled to the atmosphere.

This ammonia gas enters the tube side of an ammonia preheater where it is heated to 180-200 °F., depending upon flow rate. A bypass around the exchanger is provided in the event it must be worked on. The chemical steam that enters the shell side of the exchanger condenses and drains into the chemical condensate tank where it can be later used as make-up to No. 8 cooling tower.

FCV-1702 is located downstream of the ammonia superheater and is used to maintain constant ammonia gas pressure to the neutralizer ammonia flow valves. This valve is in operation only when the neutralizer rate is high enough to require liquid ammonia feed to the flash tank.

thus maintaining a constant pressure at the ammonia spargers.

All ammonia gas injected into a neutralizer must pass through the ammonia flow control valve which will maintain a constant feed. Bypass lines are available around the ammonia valves but under present operating conditions it is unlikely that these bypass lines would be used. A pipe loop is downstream of the control valve and serves as a check valve to prevent ammonium nitrate from backing into the ammonia lines.

After leaving the loop the ammonia splits into two streams and enters the ammonia spargers.

FRESH AMMONIA NEUTRALIZER AND MIST SEPARATOR

The ammonia and nitric acid are introduced through spargers into the inner tube of the lower section of the neutralizer. The hot reaction mass rises in the tube until it hits the conical baffle on the end and is deflected downward and outward. Enough heat is generated by the reaction so that as the mass rises the water in the nitric acid is vaporized and the solution boils. This boiling action cools the ammonium nitrate solution formed and it settles to the bottom of the neutralizer where the slightly lower pressure in the inner tube causes it to rise once again through the inner tube.

This natural thermosyphon circulation provides good mixing action, raising the conversion of the ammonia and providing a uniform acid content throughout the neutralizer.

The 90% ammonium nitrate solution leaves the neutralizer through an overflow nozzle and flows through a seal leg that prevents steam from blowing through.

The operating pressure of the chemical steam system is 1-3 psig and the pressure of the neutralizer only slightly higher. The neutralizer is protected by two rupture discs, one for pressure, set at 5 psig, and the other for vacuum, set at 1 psi below atmospheric pressure. There are two possibilities that can occur to cause vacuum.

1. The pressure controller is on manual operation and the output is such that the steam vent valve is closed and the steam within the chemical steam system condenses.
2. The neutralizer is drained with the steam vent valve shut.

The chemical steam leaves the vessel through a nozzle in the top and enters a Brink mist eliminator consisting of teflon packed filters. The Brink captures the small ammonium nitrate particles in the gas stream to prevent their release into the atmosphere. The nitrate trapped in the Brink is eventually returned to the neutralizer. The pressure drop across the Brink should be monitored to prevent it from becoming high enough to blow out the filters. A spray nozzle is located inside the Brink to wash it should the filter element become plugged.

The filtered gas stream leaves the Brink element and can be exhausted to the atmosphere or turned into the prill unit Brink scrubbers to aid in humidifying the filter elements. Each neutralizer is equipped with an automatic vent valve. An internal pressure of 1-2 psig should be maintained in the neutralizer to provide a good pH sample.

LOW CONCENTRATION

The 90% ammonium nitrate solution in 35 tank is pumped to the low concentrator through FCV-1730.

REACT SOLUTION is also fed to the low concentrator and is injected into the feed line from 35 tank at the low concentrator.

The solution feeds into a nozzle in the vapor body, is deflected downward by a baffle and falls into a weir ring around the inside of the vapor body. The solution overflows and falls to the liquid distributor plate, forms a small reservoir, and trickles through holes onto the top tube sheet of the heating element. The concentrated product leaves the coned bottom and flows by gravity to tank 36.

The temperature of the product leaving the low concentrator is sensed and FCV-1741 automatically controls the amount of steam supplied to the heating element on the low concentrator. By controlling the product stream at about 350 °F, a product concentration of 95% can be obtained.

The low concentrator is also equipped with a Brink mist eliminator to scrub the vented gas stream of ammonium nitrate particles. A seal leg designed to withstand a pressure of 2 psig is utilized to protect the vapor dome.

The concentrated product leaves the coned bottom of the low concentrator and flows by gravity to 36 tank. From 36 tank, the 95% solution is pumped through filters to the high concentrator.

HIGH CONCENTRATION

The 95% solution is pumped by 36 pump to the high concentrator. The solution enters a heating element and then falls by gravity into a vapor dome operated under a vacuum. By this method, the solution is concentrated to 99+%.

The solution temperature is sensed as it leaves the vapor dome and the steam supply to the heating element is automatically adjusted to maintain a solution temperature of about 350 °F.

The solution falls into a head tank and is prilled through one or both of two valves. The head tank has a standpipe which maintains a constant head tank level. Solution which is not prilled returns to 36 tank through the standpipe line.

HIGH CONCENTRATION, Continued

The pH of the solution entering the head tank is 3.7-4.0 pH. An ammonia sparger in the head tank is used to adjust the pH in the finished product to 5.9-6.0 pH.

HIGH CONCENTRATOR STEAM SUPPLY

Steam flow to the steam chest of the heating element is controlled by a product temperature recorded-controller alarm (TRCA 713). The main boilers supply steam at 275 psig and 535°F., super heated. Steam pressure is reduced and controlled at pressure reducing station PC739 to about 250 psig. A portion of the steam line to the concentrator is not insulated so that super heat will be dissipated. Steam flow in the 250 psig system is recorded by FR 722. A pressure indicator alarm (PIA 714) located in the steam supply at the control valve will give field indication of steam pressure and will alarm at the panel at low or high steam pressure. Steam pressure in the chest is indicated by a pressure gage which is mounted on the shell of the heating element. Steam temperature in the heating element is recorded on the panel mounted multi-point recorder alarm (TRM-1700-R). This temperature point will also have a high temperature alarm set at 410°F. Since this will be the highest temperature in the concentrator system, this alarm should be the first indication of unsafe conditions. The steam chest is fitted with a stainless steel and glass condensate level gage, which will indicate any buildup of condensate in the shell due to trap failure. A stainless steel pop warning valve is furnished on the heating element shell and this is set for 245 psig. Condensate from the steam chest will be trapped out through a bucket type trap and will be discharged into the boiler house condensate tank.

HIGH CONCENTRATOR HEATING ELEMENT

The high concentrator heating element is a long tube, vertical falling film, one pass heat exchanger with a vapor-liquid separator, condenser, and vacuum system for removing non-condensibles. The heating element liquor chamber is fitted with an eight inch rupture disc made of type 304 stainless steel designed to burst at 15 psig. at 400°F. The feed distributor for the heating element consists of the liquor chamber which is machined out of the top head of the heating element, and a distribution plate between the top head and the heating element tube sheet. The top head is machined out $\frac{1}{2}$ inch to form the liquor chamber and the distribution plate is a $\frac{3}{4}$ inch by 42 inch blank machined out to give a $\frac{1}{2}$ inch thick disc which is drilled with one $\frac{1}{8}$ inch diameter feed orifice for each of the 682 heating element tubes. The remaining $\frac{1}{4}$ inch thickness of the blank forms a spacer around the circumference so that the bottom end of the feed orifices are $\frac{1}{4}$ inch away from the top end of the heating element tubes. The distribution plate is aligned so that each orifice is directly over the center line of the tube it will feed.

HIGH CONCENTRATION, Continued

When the feed passes through the orifices, the pressure is reduced below the boiling pressure and a portion of the water in the feed flashes. This results in the atomization of the stream discharged from the orifice and formation a spray which distributes the feed on the heating element tube walls and tube sheet. From this point feed flows as a thin film down the heating element tube. As vapor is formed in the heating element tube and is heated, vapor velocity increases to approximately 324 feet per second. The high velocity vapor accelerates the liquid film on the tubes, and this high velocity in the film contributes to a high heat transfer coefficient.

HIGH CONCENTRATOR VAPOR HEAD

The mixture of liquid and vapor discharges from the bottom end of the heating element and is collected in a lower liquor chamber which has an inclined bottom to facilitate liquid flow into the vapor head. The liquid-vapor mixture from the heating element flows tangentially into the vapor head under the skirt baffle. The downward slope and curved path of the skirt baffle gives the liquid-vapor mixture a downward trajectory and a cyclonic motion. Thus the liquid droplets are directed downward and outward against the vapor head walls by centrifugal force. The liquid flows down into the cone bottom and out of the four inch discharge. A swirl breaker is fitted into the cone bottom of the vapor head to prevent the formation of a vortex in the liquid, which, if formed, could cause loss of the liquid seal in the tailpipe. The swirl breaker extends from the cone neck twelve inches up into the cone bottom. The liquid product from the high concentrator collects in the cone bottom and drains out through the seal leg into the prilling head tank.

Product temperature is measured in the seal leg and the product temperature recorder-controller-alarm (TRCA 718) records this temperature at the panel and signals the steam supply valve to the heating element to maintain temperature between 370°F. This instrument will also alarm at a product temperature of 400°F or above and shut off heating element feed.

Concentration of the product solution is 99.3-99.7%.

The vapor stream discharged from the skirt baffle flows up through the straight-side section of the vapor head with a cyclonic motion and is discharged through the 24 inch nozzle in the upper side of the vapor head. This vessel is sized so that vapor velocity will be below that necessary to carry liquid droplets out of the unit.

A 30 inch stainless steel rupture disc is mounted in the dished top of the vapor head and is designed to burst at 15 psig and 400°F.

HIGH CONCENTRATOR VACUUM SYSTEM

A vacuum measurement connection is provided at the top of the vapor head straight side and a dial type vacuum gage to be connected at this point. Also, connected to this point is the sensing element for the panel mounted vapor head absolute pressure recorder-controller-alarm (PRCA 719). A steam bleed is provided into the tubing communicating with the vapor head to prevent condensation of sublimed nitrate and plugging of the tubing. The high concentrator is designed to operate at 28 mm of Hg. absolute pressure.

The vapor head is designed to discharge against saturation pressure in the barometric condenser corresponding to the resulting cooling water temperature of 106 to 110°F. Discharge pressure shall be 60 to 66 mm. Hg. absolute (27.5 to 27.4 in Hg. vac.). Barometric vacuum is indicated by a vacuum gage. Cooling water at 87-90°F, is introduced into the barometric contact condenser at 900 GPM. This water discharges into the seal leg and then into cooling tower. Non-condensibles from the low pressure system are removed by a two stage air ejector with intercondenser. The non-condensibles and second stage steam is vented to the atmosphere. Cooling water from the intercondenser discharges into its seal leg and then into the return line to the cooling tower.

SAFETY FEATURES

The three safety features installed on the high concentrator have been already mentioned in the applicable sections, but their importance bears repeating in summary. (1) Eight inch and 30 inch diameter rupture discs are mounted on the high concentrator heating element and vapor head respectively. These discs are designed to rupture and release pressure at 15 psig at 400°F. (2) A high temperature alarm is furnished on the heating element steam temperature which is set to alarm at 410°F in the steam chest. (3) The high concentrator product temperature alarm will operate at a product temperature of 400°F. In addition to sounding an alarm at the panel board, this will also open a solenoid valve and vent diaphragm pressure from the feed flow control valve, stopping feed to the heating element.

HEAD TANK AND SPRAY HEADERS

The concentrated E-2 melt is supplied into the head tank directly from the high concentrator vapor head. A variable amount of melt overflows from the head tank and returns to 36 tank. The amount of this overflow depends upon the difference in prilling rate and high concentrator feed rate. The main portion of the melt flows out of the head tank into two headers.

The supply lines and the headers are all steam jacketed. The steam pressure in this jacketing is manually controlled in the field to a pressure equivalent to 350° F. prilling temperature. An automatic control valve placed on the inlet of each header controls the flow to each nozzle. Each header is also equipped with a steam-out system which automatically steams the header when prilling is discontinued.

TOWER

The purpose of the shot tower is to form hardened prills by cooling the sprayed nitrate as it falls. The prills are formed 3 to 6 inches from the spray nozzle. The quality of spraying determines to a great extent the quality of the finished product. The optimum spraying conditions are such that physically, the prills formed are in uniform size and are round.

The size is dependent upon the size of the spray hole, the temperature of the Nitrate, and the concentration of the Nitrate. Small variations of these three factors can greatly change the subsequent prilling conditions and the quality of the finished product. After a period of time, the nitrate will wear the nozzle holes larger. Occasional inspection and measurement of the holes should be made and nozzles with badly oversized holes be discarded. Also the plates become bulged and should be changed out.

To obtain a round prills, it is necessary that first the spray hole be round and clean. A nozzle hole may become partially plugged by foreign material. When a hole is in that condition, at the best, a small prill will be formed. The more often the hole will spray in such a manner that only dust is formed, or it will spray at an angle. When the hole sprays at an angle it may hit nitrate from good holes and make two large pellets and dust, or it may spray upon the tower cone or deck. Nitrate that sprays upon the tower structure will form lumps which may not solidify in the drop through the tower and will build up in the tower bottom. These lumps in the drying system are difficult to dry and must be removed for high quality fertilizer product. Therefore, it becomes necessary to clean the nozzles occasionally. It is necessary that all nitrate build up be kept removed from the nozzle plates.

PRILL HANDLING

The prills fall onto the conveyor belt to the cooler and pass through the prill train where they are cooled and rejects screened out. The prills should be cooled to 225 °F. before they enter the cooler. The maximum temperature exit the cooler is set at 150 °F. for bulk material. Proper temperature can be maintained by adjusting the damper on the cooler exhaust fan, by starting or stopping the two air conditioning units on each prill train, or by varying the prilling rate.

The operator in the control room can start or stop the prill trains from a remote control panel. A manual-auto switch in the field allows the solids rover to take control of the prill trains. When the switch is in the manual position, the operator in the control room cannot start the prill train although he still has control of the fans.

A closed circuit TV system monitors the back end of the cooler and the Sweco to give the operator a visual indication of operation of a prill unit. *check in holding?*

Since the prill units can be started remotely, safety becomes the prime concern. Prior to starting a unit, the operator presses a start sequence button. A horn and flashing light signal personnel in the area that a prill unit is about to be started. After 45 seconds, the interlocks time out and the unit can be started. The horn and flashing light will continue to operate until the conveyor to the cooler, the last equipment in the train, starts.

The prill train is interlocked so that a failure of a piece of equipment will shut down all equipment behind the item that failed. The cooler exhaust and tower cone fan are not interlocked and can be started or stopped without effect on the rest of the train.

PRILL MOISTURE CONTROL IN COOLER

The moisture content of the dried and cooled prill is depending upon 1. Prill pH, 2. Prill physical strength, 3. Tower temperature, 4. Prill size, 5. Prill shape, 6. Prill temperature, 7. Cooler air inlet temperature, 8. Cooler exit air temperature, 9. Outside air moisture content, 10. Prill time in cooler, 11. Air flow through the cooler.

PRILL MOISTURE CONTROL IN COOLERS, Continued

With a prill pH of 3.4 or less, moisture is united with free acid. This moisture is very difficult to remove and could only be done with excessive temperatures, which would break the prill. The prill pH should be maintained between 5.0 and 6.0.

The prill of poor physical strength tends to break and crumble in the process cooler. When the prill breaks more surface per weight is exposed and moisture is more readily absorbed from the atmosphere. The dusty nitrate product is almost invariably of high moisture content. The dust is formed when the prill breaks due to improper processing in the tower or in the drying section.

In the tower the prill surface tends to cool before the center due to expansion at the transition temperature of 184°F. When the prill is excessively large or the tower is excessively cold surface cooling is rapid and thermostress is sufficient to weaken the prill and make the formation of dust in the drying system more likely. The prill should be cooled to under 250°F in the tower (actual practice), and actual maximum temperature of 250°F must be observed. When the prill leaves the tower at a higher temperature than this transition point the pellet passes rapidly through this point in the cooler and will break up into dust.

The large prill is more difficult to dry than a smaller one. There is a greater distance for the moisture to travel from the inside to the surface to be released. In the larger prill, the surface dries relatively faster than the center and the dry nitrate forms a surface crust which acts somewhat as a barrier against escape of the internal moisture.

During the drying of the irregular shaped prill non-uniform stresses are produced, which weaken the prill and make it more susceptible to breakage. These stresses are formed due to the transition point, the crust form, and localized points of moisture release. If the prill is either above 154°F in the drying process, the transition point is again gone through. Going upward through this temperature point the prill surface shrinks and causes the prill to crack and tend to break into dust. With a too hot prill, there is a tendency for the moisture to attempt to escape too rapidly and the prill burst as popcorn pops.

The temperature of the air entering the coolers is regulated so that the temperature of the Prill decreases slightly throughout the drying process. A large temperature difference between the air and the prill is to be avoided because such a thermoshock is detrimental to prill strength. When the air temperature is excessively high, too rapid drying is attempted and the moisture cannot escape in the normal manner fast enough and the prill bursts.

2-40

PRILL MOISTURE CONTROL IN COOLER, Continued

In the cooler the flow of air is counter-current to the flow of prills. In other words, the prills move against the cooler air flow. Because of this type of conveyance to the cooler a very low rate of production is very difficult since the prill will be moved through the cooler too fast to allow the moisture to come to the surface.

The outside air moisture content determines the drying capacity of the air. The more moisture in the air, the less moisture the air can take up at a given temperature. Do not confuse moisture content with relative humidity. Cold air of high relative humidity, when it is heated, often can take on more moisture than warm air of lower relative humidity when heated to the same temperature. Thus, more effective drying of a larger amount of prill can be done at a lower temperature in winter than a smaller amount of prills at a higher temperature in the summer.

The longer the prills stays in the cooler, the more time it is exposed to the drying action. With a small prill flow, it is very difficult to establish a smooth rate of drying. The smooth rate of drying decrease the percentage of nitrate lost to breakage and dust formation. Nitrate build-up on the cooler lifters and shell decreases the retention time of the prill and makes drying more difficult. Build-up of nitrate in the cooler is also a source of dust when cooler conditions change and nitrate dust always results in poor moisture control. Moisture content, %E -2 and pH should be check every two hours on each unit to maintain proper quality.

| | |
|----------------|----------------------|
| Moisture Limit | .5% H ₂ O |
| %E -2 Limit | .4 to .6% |
| pH Limit | 5.5 to 6.5 pH |

TOWER BRINK SCRUBBER

The function of the prill unit scrubber is to remove the entrained ammonium nitrate particles from that portion of the tower air that is pulled through the tower cone. The air pulled through the cone may only be about one-fourth of the total tower air flow, but it will contain nearly all of the nitrate dust emission from the tower. It would not be economical to scrub the total tower air flow. The capital expense involved and the energy cost to operate such a system would be enormous compared to the scrubber design that is used at this plant.

The scrubber system makes use of the phenomena that the nitrate solution will disassociate, or fume, in a relatively short section of the shot tower as it is sprayed and begins to cool on its way to the bottom of the tower. The solution is sprayed at 350°F. through a cone 45' in length. At the bottom of the cone the melt solution has cooled to 300°F. and has begun to solidify. The solution has also given off most of the small nitrate particles which would give the tower exhaust a bluish, hazy look if it were allowed to vent unscrubbed to the air.

The tower fan on the back end of the unit takes suction on the tower cone and exhausts the air stream, rich in nitrate dust, into the lower portion of the scrubber vessel.

The scrubber vessel contains 42 Brink filter elements suspended at the top of the vessel from a tube sheet. The Brink elements will entrap the nitrate particles in the air stream. These elements are continually wetted by a fine fog from 112 spray nozzles located around the filter elements and the trapped nitrate particles will be washed back to the scrubber sump. The feed for these nozzles is supplied from the discharge line of the cooling tower pump.

A pre-filter is located below the Brink elements. Its purpose is to prevent the larger nitrate particles from impinging on the Brink elements with resulting plugging. The pre-filter is wetted from a system of spray nozzles located above and below the pre-filter.

The bottom of the scrubber contains some 3,700 gallons of nitrate solution which will vary in concentration from 15% to 60%. This sump serves as reservoir from which a pump continuously circulates 360 GPM through the pre-filter spray nozzles. The flow does not split evenly through all nozzles. The bottom nozzles spray 300 GPM on the underside of the pre-filter. This is to assure that the pre-filter is saturated as the spray is cocurrent with the air flow through the scrubber. The remaining 60 GPM is sprayed on the top of the pre-filter.

The scrubber circulation flow is controlled manually by adjusting a manual controller on FCV-2. The controller and FCV-2 are located in the field between the scrubber units.

TOWER BRINK SCRUBBER, Continued

Make-up to the scrubber sump is on level control from No. 8 cooling tower through LCV-1. There is no blowdown on No. 8 cooling tower, so the nitrate picked up in the barometric condenser stays in the cooling tower loop where it concentrates up to 12-15%. The scrubber sump should then contain at least a 12-15% nitrate solution at all times.

As the tower fan exhausts into the scrubber the nitrate particles are scrubbed from the air stream and eventually fall to the sump. The process continues with the scrubber utilizing the hot fan exhaust to evaporate water from the circulating nitrate streams. The circulating nitrate solution will, in this manner, slowly increase in concentration.

The conductivity of a nitrate solution is an indirect measurement of its concentration. A conductivity sensing element, CT-3, is located downstream of FCV-2 and as the conductivity approaches a value comparable to a 60% concentration, CCV-3 opens to allow a side-stream from the sump to flow to the auxiliary concentrator surge tank.

Provision is made to put the neutralizer stacks into the scrubber if desired. The primary reason is to recover the nitrate particles and ammonia that escape the neutralizer Brinks. The added heat from the chemical steam would also assist in concentrating the nitrate solution circulating in the scrubber. PCV-1 will maintain the internal pressure in the neutralizers at the desired point, usually 1-2 psig.

Putting the neutralizer stacks into the scrubber presents a problem. The filter media used in the Brink filter elements will be destroyed if subjected to an ammonia atmosphere over a period of time.

Since the neutralizer chemical steam exhaust is always on the ammonia side, a pH control system is provided for the scrubber sump.

The pH of the circulating solution in the sump is sensed and nitric acid is introduced through PNCV-4 into the circulating line just ahead of the pre-filter spray nozzles. The pH of the sump will be controlled at a pH of 2.

As the ammonia gas in the neutralizer chemical steam passes through the area of the pre-filter, ammonium nitrate is formed and the ammonia gas is prevented from reaching the Brink filters.

A spray system supplied from the discharge of the cooling tower pump is installed in the horizontal run of the air duct from the tower cone. Its purpose is to prevent a dust build-up in this section of the duct. A small dam is provided and the collected liquid falls by gravity into the return line from the barometric condenser.

TOWER BREK SCRUBBER, Contin

Filters are provided ahead of the scrubber spray nozzles and make-up to the scrubber sump. The filter should be cleaned each shift. A filter is also provided ahead of the duct sprays.

Make-up to No. 8 Cooling Tower is on level control through LCV-9 from the neutralizer chemical condensate tank. A condensate line from the Area III condensate tank is connected to the chemical condensate tank at the neutralizers to provide make-up when both neutralizers are down.

As the prill stream leaves the tower cone it is control through LCV-9 from the neutralizer chemical condensate tank at the neutralizers to provide make-up when both neutralizers are down.

As the prill stream leaves the tower cone it is cooled further by the air flow provided by three fans located in the side of the tower. The nitrate solution was sprayed at 350°F and was cooled to 300°F at the bottom of the cone. When the prills fall to the conveyor belt to the cooler, they will have cooled to 220-230°F.

AUXILIARY CONCENTRATOR

This concentrator is fed with weak recovered nitrate solutions that are collected throughout the plant. The primary function is to reduce the load on the main concentrators. It is fed with solutions from the air washer tanks, shot tower troughs, remelt ditch and waste recovery tank. The feed from the shot tower troughs and the air washer tanks is continuous and the feed from the remelt tanks and the waste recovery tanks is intermittent. Concentration of the feed varies from 40 to 70%.

The concentrator consists of a storage tank, pump, steam heater and elevated flash tank. It is operated continuously with the concentrated nitrate solution being discharged into 35 tank. No attempt is made to regulate concentration of the finished nitrate. The tank is equipped with a level indicator. The heater is equipped with a temperature controller that maintains the exit nitrate temperature at 300°F. Circulation is continuous and is not throttled. The solution from the heater passes up to an elevated flash tank that is open to atmospheric pressure. The water will flash from the solution and the cooled solution will fall freely back to the storage tank. As water is flashed from the nitrate solution the level in the tank decreases allowing the remelt ditch to flow into the storage tank. When the high level alarm sounds on the remelt ditch, pump the storage tank to 35 tank. This will allow remelt to flow into the auxiliary storage tank. Stop pumping when the high alarm shuts off. Prolonged running of the auxiliary concentrator can cause the remelt ditch to run dry.

LOCATION: PA #2 (2) DATE: 2/19/75 TIME: 6PM BY: LAB

RAC FIELD DATA SHEET

| POINT # | SAMPLE TIME (min) | STATIC PRESSURE P ₀ (IN. HG) | STACK TEMP T _s (°F) | VELOCITY HEAD VP (IN. H ₂ O) | ΔH (IN. H ₂ O) | METERS | | GAS VOLUME V ₀ (LBS) | VACUUM (IN. HG) | MANIFESTER TEMP (°F) | SAMPLE BOX TEMP (°F) |
|---------------|-------------------|---|--------------------------------|---|---------------------------|---------------|----------------|---------------------------------|-----------------|----------------------|----------------------|
| | | | | | | INLET TM (°F) | OUTLET TM (°F) | | | | |
| 1 | 5 | 1.62 | 4.5 | 3.2 | 1.55 | 7.0 | 0.2615 | 5.5 | 5.5 | 5.0 | 5.0 |
| 2 | - | - | - | 4.0 | 1.60 | 7.0 | - | - | - | 5.0 | - |
| 3 | - | - | - | 4.3 | 1.80 | 7.8 | - | - | - | 5.5 | - |
| 4 | - | - | - | 4.0 | 1.70 | 7.7 | - | - | - | 5.6 | - |
| 5 | - | - | - | 4.0 | 1.60 | 8.0 | - | - | - | 5.8 | - |
| 6 | - | - | - | 2.8 | 1.1 | 6.6 | - | - | - | 5.0 | - |
| 7 | - | - | - | 3.5 | 1.41 | 7.7 | - | - | - | 5.0 | - |
| 8 | - | - | - | 2.8 | 1.50 | 8.8 | - | - | - | 5.0 | - |
| 9 | - | - | - | 4.0 | 1.50 | 8.9 | - | - | - | 5.5 | - |
| 10 | - | - | - | 4.3 | 1.50 | 8.8 | - | - | - | 5.5 | - |
| 11 | - | - | - | 2.7 | 1.50 | 7.7 | - | - | - | 5.7 | - |
| 12 | - | - | - | 4.0 | 1.60 | 8.8 | - | - | - | 5.7 | - |
| 13 | - | - | - | 2.8 | 1.1 | 7.7 | - | - | - | 5.8 | - |
| 14 | - | - | - | 3.5 | 1.41 | 8.8 | 73.27 | - | - | 5.8 | - |
| 15 | - | - | - | - | - | - | - | - | - | - | - |
| 16 | - | - | - | - | - | - | - | - | - | - | - |
| 17 | - | - | - | - | - | - | - | - | - | - | - |
| 18 | - | - | - | - | - | - | - | - | - | - | - |
| 19 | - | - | - | - | - | - | - | - | - | - | - |
| 20 | - | - | - | - | - | - | - | - | - | - | - |
| 21 | - | - | - | - | - | - | - | - | - | - | - |
| 22 | - | - | - | - | - | - | - | - | - | - | - |
| 23 | - | - | - | - | - | - | - | - | - | - | - |
| 24 | - | - | - | - | - | - | - | - | - | - | - |
| TOTAL AVERAGE | | | | | 1.55 | | 216.987 | 5.3 | | | |

METER ΔHD = 1.84
 AMBIENT TEMP. °F
 BAROMETRIC PRESSURE 30.12 IN. Hg
 STATIC PRESSURE 1.62 IN. Hg
 C. FACTOR 1.0
 ASSUMED MOISTURE 3.12%
 PROBE SIZE 1/16 IN.
 PROBE AREA π(0.00545) = 0.000742 (sq in)
 LEAK CHECK 0.2 ft³
 P₀ = BP + STATIC = 20.12 + 1.6 = 19.5

LOCATION: DA # 2 (3) DATE: 2/19/75 TIME: 6:41 BY: LAR

RAC FIELD DATA SHEET

| POINT # | SAMPLE TIME (min) | STATIC PRESSURE P ₀ (IN. Hg) | STACK TEMP T _s (°F) | VELOCITY HEAD ΔP (IN. H ₂ O) | ΔH (IN. H ₂ O) | METER | | GAS VOLUME V ₀ (LBS) | VACUUM (IN. H ₂) | WINDSPEED (MPH) | SAMPLE BOX TEMP (°F) |
|---------|-------------------|---|--------------------------------|---|---------------------------|---------------------------|----------------------------|---------------------------------|------------------------------|-----------------|----------------------|
| | | | | | | INLET T _m (°F) | OUTLET T _o (°F) | | | | |
| 1 | 5 | 1.6 | 95 | 4.1 | 1.2 | 77 | 77 | 17307 | 6 | 60 | 2.0 |
| 2 | — | — | — | 4.1 | 1.5 | 83 | 71 | — | 6 | 62 | — |
| 3 | — | — | — | 4.6 | 2.0 | 91 | 74 | — | 6 | 62 | — |
| 4 | — | — | — | 4.1 | 1.5 | 84 | 72 | — | 6 | 64 | — |
| 5 | — | — | — | 4.0 | 1.7 | 86 | 74 | — | 6 | 62 | — |
| 6 | — | — | — | 2.9 | 1.3 | 80 | 71 | — | 6 | 62 | — |
| 7 | — | — | — | 3.5 | 1.5 | 82 | 66 | — | 6 | 62 | — |
| 8 | — | — | — | 4.1 | 1.7 | 82 | 71 | — | 6 | 62 | — |
| 9 | — | — | — | 4.6 | 2.0 | 88 | 77 | — | 6 | 62 | — |
| 10 | — | — | — | 4.4 | 1.9 | 82 | 74 | — | 6 | 62 | — |
| 11 | — | — | — | 4.0 | 1.7 | 80 | 71 | — | 6 | 60 | — |
| 12 | — | — | — | 4.0 | 1.7 | 80 | 71 | — | 6 | 60 | — |
| 13 | — | — | — | 2.9 | 1.3 | 80 | 69 | — | 6 | 61 | — |
| 14 | — | — | — | 3.5 | 1.5 | 84 | 74 | 18505 | 6 | 61 | — |
| 15 | — | — | — | — | — | — | — | — | — | — | — |
| 16 | — | — | — | — | — | — | — | — | — | — | — |
| 17 | — | — | — | — | — | — | — | — | — | — | — |
| 18 | — | — | — | — | — | — | — | — | — | — | — |
| 19 | — | — | — | — | — | — | — | — | — | — | — |
| 20 | — | — | — | — | — | — | — | — | — | — | — |
| 21 | — | — | — | — | — | — | — | — | — | — | — |
| 22 | — | — | — | — | — | — | — | — | — | — | — |
| 23 | — | — | — | — | — | — | — | — | — | — | — |
| 24 | — | — | — | — | — | — | — | — | — | — | — |
| TOTAL | 70 | | | | | | | | | | |
| AVERAGE | | | | | 1.74 | 89 | 73 | 18535 | 5.6 | | |

METER ΔHD = 1.34
 AMBIENT TEMP. OF
 BAROMETRIC PRESSURE 30.12 IN. Hg
 STATIC PRESSURE 1.6 IN. Hg
 STATIC PRESSURE 1.6 IN. Hg
 C. FACTOR 1.1
 ASSUMED MOISTURE 2%
 PROBE SIZE 1/4 IN.
 PROBE AREA 0.000545 = 0.00107 ft² (A_p)
 LEAK CHECK 0.2 ft³
 P₀ = RAC STATIC = 30.12 ± 1.6 = 9.5

PARTICULATE
RAC CALCULATION SHEET

| | | | | |
|----------------|-------------|--------------------|---------------------|---------|
| LOCATION #2 | DATE 2/7/75 | TIME 6:00 | SAMPLE # 1 | BY: JAP |
| DRY GAS VOLUME | | $V_{mSTD} = 39.21$ | ft ³ DRY | |

$$V_{mSTD} = V_m (19.7) \left(\frac{P_{BAR} + \Delta H / 13.6}{T_m + 460} \right) = (47.72) (19.7) \frac{24.89 + 1.61 / 13.6}{(555)} = 24.89 + 1.61 / 13.6$$

VOLUME of WATER VAPOR $V_{wSTD} = 1.42$ ft³

$$V_{wSTD} V_{ic} (0.0474) = 29.92 (0.0474) = 1.42$$

MOISTURE CONTENT $B_{w0} = 3.49$ 400 mg

$$B_{w0} = \frac{V_{wSTD}}{V_{mSTD} + V_{wSTD}} = \frac{1.42}{39.21 + 1.42}$$

CONCENTRATION $C_s = 1.14 \times 10^{-2}$ GRAMS/SCF

$$C_s = (0.0154) \left[\frac{mg}{V_{mSTD}} \right] = (0.0154) \left[\frac{29.92}{39.21} \right]$$

$$C_s = 1.63 \times 10^{-6} \text{ lb/scf}$$

$$C_s = 2.205 \times 10^{-6} \left[\frac{mg}{V_{mSTD}} \right] = 2.205 \times 10^{-6} \left[\frac{29.92}{39.21} \right]$$

ISOKINETIC VARIATION

$I = 103$ % [GOOD IF 90 TO 110%]

$$I = \frac{(T_s + 460) (1.667) \left[(0.00267) V_{ic} \right] + \left[\frac{V_m}{T_m + 460} (P_{BAR} + \Delta H / 13.6) \right]}{(T_s + 460) (1.667) \left[(0.00267) V_{ic} \right] + \left[\frac{V_m}{T_m + 460} (P_{BAR} + \Delta H / 13.6) \right]}$$

$$I = \frac{(555) (1.667) \left[(0.00267) (29.92) \right] + \left[\frac{(47.72)}{555} (39.12) + (1.61) / 13.6 \right]}{(70) (1.667) \left[(0.00267) (29.92) \right] + \left[\frac{(47.72)}{555} (39.12) + (1.61) / 13.6 \right]}$$

EMISSIONS

$Q_{ASTD} = 1795266$ SCFH DRY BASIS

$$E = Q_{ASTD} \times C_s = 1795266 \text{ SCFH} \times 1.63 \times 10^{-6} \text{ lb/scf} = 2.93 \text{ lb/hr AN}$$

$$2.25 \times 10^{-6} \text{ lb/scf} = 40 \text{ lb/hr NH}_3$$

| MILIGRAMS COLLECTED | |
|-------------------------|-------|
| PROBE | ✓ |
| CYCLONE | ✓ |
| FILTER | ✓ |
| TOTAL (mg) | 29 |
| IMPINGER (Vic) | 21 |
| IMPINGER (mg) | ✓ |
| $T_s + 460$ | 555 |
| Vic | 29.92 |
| V_m | 47.72 |
| $T_m + 460$ | 555 |
| $\Delta H / 13.6$ | 1.61 |
| \odot (CORRECTION) | ✓ |
| V_s (VOLUME) | 117 |
| $P_s + 13.6$ (P. RES) | 24.89 |
| AN (AREA NOZZLE) | ✓ |
| $P_{BAR} = BP - VACUUM$ | 24.89 |

3 Fans Tower
1 2nd Tower

PARTICULATE ()
RAC CALCULATION SHEET

| | | | | |
|----------------|--------------|-----------------|---------------------|--------|
| LOCATION PA#2 | DATE 7/18/75 | TIME 6 P | SAMPLE # 2 | BY LHB |
| DRY GAS VOLUME | | $V_{MSTD} = 27$ | FE ³ DRY | |

$$V_{ASTO} = V_M (19.71) \frac{(P_{BAR} + \Delta H / 13.6)}{T_{MST}} = (46.457 \times 19.71) \frac{24.22 + 1.55 / 13.6}{(525)}$$

VOLUME of WATER VAPOR $V_{WSTD} = 1.25$ ft³

$$V_{WSTD} \times V_{ic} (0.0154) = 2.32 \text{ ml } (0.0074) = \text{Nil}$$

MOISTURE CONTENT $B_{W0} = 3.16$ 285 mg

$$B_{W0} = \frac{V_{WSTD}}{V_{MSTD} + V_{WSTD}} = \frac{(1.25)}{27.25 + 1.25}$$

CONCENTRATION $C_{S1} = 4.2 \times 10^{-3}$ GRAMS/SCF

$$C_{S1} = (0.0154) \left[\frac{MA}{V_{MSTD}} \right] = (0.0154) \left[\frac{(10.5)}{2.5} \right]$$

$$C_{S2} = 6.0 \times 10^{-7} \text{ lb/SCF}$$

$$C_{S2} = 2.205 \times 10^{-6} \left[\frac{MA}{V_{MSTD}} \right] = 2.205 \times 10^{-6} \left[\frac{10.5}{36.35} \right]$$

ISOKINETIC VARIATION $I = 100.8$ % [GOOD IF 90 TO 110%]

$$I = \frac{(T_3 + 460) \times 1.667 \left[(0.00264) V_{ic} \right] + \left[(V_M / T_{MST} + 460) (P_{BAR} + \Delta H / 13.6) \right]}{(6) (V_S) (C_{S1} \text{ or } C_{S2})}$$

$$I = \frac{(555) (1.667) \left[(0.00264) (2.32) \right] + \left[(46.457 / 525) (24.22 + 1.55 / 13.6) \right]}{(70) (116) (2.205 \times 10^{-6})}$$

EMISSIONS $Q_{ASTD} = 1795266$ SCFH DRY BASIS

$$E = Q_{ASTD} \times C_{S2} = 1795266 \text{ SCFH} \times 6.0 \times 10^{-7} \text{ lb/SCF} = 1.08 \text{ lb/HR (AN)}$$

$$164 \times 10^{-3} \text{ lb/SCF} = 29.4 \text{ lb/HR (N#3)}$$

| MILIGRAMS COLLECTED | |
|-------------------------|---------|
| DOSE | 2.5 |
| CYCLONE | 0 |
| FILTER | 0.0 |
| TOTAL (MA) | 10.5 |
| IMPINGER (Vic) | 1.8 |
| IMPINGER (mg) | 2.32 |
| $T_3 = 460$ | 555 |
| Vic | 2.32 |
| Vm | 46.457 |
| $T_{MST} = 460$ | 525 |
| $\Delta H / 13.6$ | 1.55 |
| \odot (GROSS TIME) | 1.0 |
| Vs (VELOCITY) | 116 |
| Ps = 29.92 (32.00) (in) | 2.5 |
| AIN (AREA NOZZLE) | 0.00264 |
| PBAR = BP - VACUUM | 24.22 |

3 Fans
 1 Spox Tower

RAC CALCULATION SHEET

| | | | | |
|----------------|--------------|-----------------|---------------------|--------|
| LOCATION PA#2 | DATE 2/11/75 | TIME 6 P | SAMPLE # 3 | BY LAB |
| DRY GAS VOLUME | | $V_{mSTD} = 31$ | ft ³ DRY | |

$$V_{mSTD} = V_m (19.71) \left(\frac{P_{BAR} + \Delta H / 13.6}{T_m + 460} \right) = (49.235) (19.71) \frac{24.52 + 1.74 / 13.6}{(19.71)}$$

VOLUME of WATER VAPOR $V_{wSTD} = 1.4$ ft³

$V_{wSTD} V_{ic} (0.0474) = 29.5$ ml (0.0474) = NH₃

MOISTURE CONTENT $B_{w0} = 3.45$

$B_{w0} = \frac{V_{wSTD}}{V_{mSTD} + V_{wSTD}} = \frac{(1.4)}{29.21 + 1.4}$

CONCENTRATION $C_{g1} = 6.07 \times 10^{-3}$ GRAMS/SCF

$C_{g1} = (0.0154) \left[\frac{mg}{V_{mSTD}} \right] = (0.0154) \left[\frac{(15.5)}{31.2} \right]$

$C_{g2} = 8.7 \times 10^{-7}$ lb/SCF

$C_{g2} = 2.205 \times 10^{-6} \left[\frac{mg}{V_{mSTD}} \right] = 2.205 \times 10^{-6} \left[\frac{15.5}{31.2} \right]$

| MILIGRAMS COLLECTED | |
|--------------------------------|--------|
| DRY GASE | 8.5 |
| CYCLONE | 1.0 |
| FILTER | 0.5 |
| TOTAL (MA) | 10.0 |
| IMPINGER (V _{ic}) | 21 |
| IMPINGER MG. | 2.5 |
| Ts + 460 | 555 |
| V _{ic} | 0.0474 |
| V _m | 49.235 |
| T _m + 460 | 597 |
| ΔH / 13.6 | 1.74 |
| ⊖ (CORRECTION) | 70 |
| V _s (CORRECTION) | 116 |
| P _{BAR} = BP - VACUUM | 29.92 |
| AN (AREA NOZZLE) | 0.5 |

ISOKINETIC VARIATION $I = 104$ % [GOOD IF 90 TO 110 %]

$$I = \frac{(T_s + 460) (1.667) [(0.00267) V_{ic}] + [(V_m / (T_m + 460)) (P_{BAR} + \Delta H / 13.6)]}{(70) (116) (0.52) (0.00267)}$$

$$I = \frac{(555) (1.667) [(0.00267) (29.5)] + [(49.235) / (597)] [(29.92) + (1.74) / 13.6]}{(70) (116) (0.52) (0.00267)}$$

EMISSIONS $Q_{ASTD} = 1795.266$ SCFH DRY GAS

$E = Q_{ASTD} \times C_{g2} = 1795.266 \text{ SCFH} \times 8.7 \times 10^{-7} \text{ lb/SCF} = 1.56 \text{ lb/HR AN}$

$2.95 \times 10^{-5} \text{ lb/SCF} = 53 \text{ lb/HR NH}_3$

- 3 TOWER FANS
- 1 SHOT TOWER FAN

STACK VELOCITY CALCULATION SHEET

| # | IN. | TEMP. t_s , °F | STATIC PRESS. P_s , IN H ₂ O | ΔP IN H ₂ O | $\sqrt{\Delta P}$ IN H ₂ O |
|--------------------------------|---------|------------------|---|--------------------------------|---------------------------------------|
| 1 | 1/4 | 46 | 1.6 | 1.7 | 1.3 |
| 2 | 2 3/8 | — | — | 2.0 | 1.41 |
| 3 | 4 1/2 | — | — | 1.9 | 1.37 |
| 4 | 6 7/8 | — | — | 1.8 | 1.34 |
| 5 | 10 1/2 | — | — | 2.7 | 1.64 |
| 6 | 14 1/2 | — | — | 2.7 | 1.64 |
| 7 | 18 1/2 | — | — | 2.7 | 1.64 |
| 8 | 22 1/2 | — | — | 2.7 | 1.64 |
| 9 | 26 1/2 | — | — | 2.7 | 1.64 |
| 10 | 30 1/2 | — | — | 2.7 | 1.64 |
| 11 | 34 1/2 | — | — | 2.7 | 1.64 |
| 12 | 38 1/2 | — | — | 2.7 | 1.64 |
| 13 | 42 1/2 | — | — | 2.7 | 1.64 |
| 14 | 46 1/2 | — | — | 2.7 | 1.64 |
| 15 | 50 1/2 | — | — | 2.7 | 1.64 |
| 16 | 54 1/2 | — | — | 2.7 | 1.64 |
| 17 | 58 1/2 | — | — | 2.7 | 1.64 |
| 18 | 62 1/2 | — | — | 2.7 | 1.64 |
| 19 | 66 1/2 | — | — | 2.7 | 1.64 |
| 20 | 70 1/2 | — | — | 2.7 | 1.64 |
| 21 | 74 1/2 | — | — | 2.7 | 1.64 |
| 22 | 78 1/2 | — | — | 2.7 | 1.64 |
| 23 | 82 1/2 | — | — | 2.7 | 1.64 |
| 24 | 86 1/2 | — | — | 2.7 | 1.64 |
| 25 | 90 1/2 | — | — | 2.7 | 1.64 |
| 26 | 94 1/2 | — | — | 2.7 | 1.64 |
| 27 | 98 1/2 | — | — | 2.7 | 1.64 |
| 28 | 102 1/2 | — | — | 2.7 | 1.64 |
| 29 | 106 1/2 | — | — | 2.7 | 1.64 |
| 30 | 110 1/2 | — | — | 2.7 | 1.64 |
| 31 | 114 1/2 | — | — | 2.7 | 1.64 |
| 32 | 118 1/2 | — | — | 2.7 | 1.64 |
| 33 | 122 1/2 | — | — | 2.7 | 1.64 |
| 34 | 126 1/2 | — | — | 2.7 | 1.64 |
| 35 | 130 1/2 | — | — | 2.7 | 1.64 |
| 36 | 134 1/2 | — | — | 2.7 | 1.64 |
| 37 | 138 1/2 | — | — | 2.7 | 1.64 |
| 38 | 142 1/2 | — | — | 2.7 | 1.64 |
| 39 | 146 1/2 | — | — | 2.7 | 1.64 |
| 40 | 150 1/2 | — | — | 2.7 | 1.64 |
| 41 | 154 1/2 | — | — | 2.7 | 1.64 |
| 42 | 158 1/2 | — | — | 2.7 | 1.64 |
| 43 | 162 1/2 | — | — | 2.7 | 1.64 |
| 44 | 166 1/2 | — | — | 2.7 | 1.64 |
| 45 | 170 1/2 | — | — | 2.7 | 1.64 |
| 46 | 174 1/2 | — | — | 2.7 | 1.64 |
| 47 | 178 1/2 | — | — | 2.7 | 1.64 |
| 48 | 182 1/2 | — | — | 2.7 | 1.64 |
| 49 | 186 1/2 | — | — | 2.7 | 1.64 |
| 50 | 190 1/2 | — | — | 2.7 | 1.64 |
| 51 | 194 1/2 | — | — | 2.7 | 1.64 |
| 52 | 198 1/2 | — | — | 2.7 | 1.64 |
| 53 | 202 1/2 | — | — | 2.7 | 1.64 |
| 54 | 206 1/2 | — | — | 2.7 | 1.64 |
| 55 | 210 1/2 | — | — | 2.7 | 1.64 |
| 56 | 214 1/2 | — | — | 2.7 | 1.64 |
| 57 | 218 1/2 | — | — | 2.7 | 1.64 |
| 58 | 222 1/2 | — | — | 2.7 | 1.64 |
| 59 | 226 1/2 | — | — | 2.7 | 1.64 |
| 60 | 230 1/2 | — | — | 2.7 | 1.64 |
| TOTALS | | | | 327 | 1.64 |
| AVERAGE | | | | 1.04 | |
| RES. TEMP. $T_s = t_s + 460 =$ | | | | | OR |

| COMPONENT | Vol % | MOL. WGT | WGT % |
|----------------|-------|----------|-------|
| O ₂ | | 44 | |
| CO | | 28 | |
| O ₂ | | 32 | |
| N ₂ | | 28 | |

AVERAGE M_w = _____

LOCATION: _____ NO. _____ By: _____
 DATE: 2/5/75
 TIME: 3:00 PM
 AMBIENT DRY: _____ OF _____
 WET: _____ OF _____
 ABS. HUMIDITY: _____ %
 BAROMETRIC: _____ mmHg
 P_{BAR} × (0.04) = 22.93 in Hg
 PROCESS DRY: _____ OF _____
 WET: _____ OF _____
 ABS. HUMIDITY W: _____ %
 STACK AREA A_s: 4.9 ft²
 PITOT FACTOR V_s: 1.0
 S = W: .0301
 S' = S × 1.61: .0483

$P_s =$ _____ in H₂O (0.0735) = 1.6 in Hg $P_A = P_s = 27.93 = 1.6 = 28.33$ in Hg

$M_p = \frac{(M Y) + S}{(1 + S)} = \frac{(29 \times 1) + .03}{(1 + .0301)} = 28.47$ #/mol

DENSITY = $\frac{0.0459(M_p)(P_A + P_s)}{T_s + 460} = \frac{0.0459 \times 28.47 \times 28.33}{(556)} = 0.67$ #/ft³

AVERAGE $\Delta P = \left[\frac{\sum (F_i)(\sqrt{\Delta P_i})}{\# \text{ POINTS}} \right]^2 = \left[\frac{(1) \times (1.64)}{(18)} \right]^2 = (1.41)^2 = 1.99$ IN H₂O

AVERAGE $V_s = \sqrt{\frac{(334) \times (\text{AVE. } \Delta P)}{\text{DENSITY}}} = \sqrt{\frac{(334) \times (1.99)}{(0.667)}} = 99.82$ FPS

$Q_p = 60 V_p A = 60(99.82 \times 4.9) = 29,247$ ACFM (WET)

$Q_s = \left[\frac{S'}{(1.0 + S')} \right] Q_p = \left[\frac{(.0483)}{(1.0 + .0483)} \right] Q_p = 1352$ ACFM $Q_p - Q_s = 27995$ ACFM (DRY) = Q_d

$W_p = 60 Q_p (\text{DENSITY}) = 60(29,247) \times (0.667) = 11,680$ #/HR (WET)

$W_s = \left[\frac{S}{(1.0 + S)} \right] W_p = W_p \left[\frac{(.03)}{(1.0 + .03)} \right] = 850$ #/HR $W_p - W_s = 10,830$ #/HR (DRY) = W_d

$Q_{STD} = \frac{Q_d (14.7)(P_s = P_s)}{T_s + 460} = \frac{(27995 \times 14.7 \times 28.33)}{(556)} \times 60 = 1515700$ ✓ SCFH (DRY)

% H₂O = $Q_d / Q_p = \frac{1352}{29247} \times 100 = 4.62$ % H₂O

BRINK MIST SAMPLER DATA

LOCATION PA #2 TIME 3PM DATE 2/5/79 SAMPLE 1
 PROCESS TEMP 556 OR BRINK SP 1.5 IN Hg
 BP + SP 22.2 IN Hg

4" mm PIPE ⇒ .81 CFM ⇒ 1.67 ΔP IN H₂O

1.67 ΔP₀ × 17.71 × 22.2 BP+SP / 556 T_s = 1.52 ΔP_{IN}

1.52 AVE ΔP FOR RUN

1.52 ΔP × 0.00557 × T_s 556 / 22.2 BP+SP

1.67 ΔP₀ ⇒ .81 CFM × 56 SAMPLE TIME 5

43.36 ft³ COLLECTED × 17.71 × 22.2 / BP+ΔP₀ / 13.6 / T_s 556

43.4 SCF COLLECTED

| | CYCLONE + FILTER | IMPINGER | TOTAL |
|--------------------------------|------------------|----------|-------|
| | mg | mg | mg |
| AN | 0 | 0 | 0 |
| NH ₃ | 0 | 111 | 111 |
| HNO ₃ | | | |
| H ₂ SO ₄ | | | |

EMISSIONS:

(9) Mg × 2.205 × 10⁻⁶ × 15 / 5702 SCFH = 0.7 lb
 (43.4) SCF

| | | |
|--------------------------------|-----|-------|
| AN | 0.7 | lb/HR |
| NH ₃ | 2.5 | lb/HR |
| HNO ₃ | | lb/HR |
| H ₂ SO ₄ | | lb/HR |

BRINK MIST SAMPLER DATA

LOCATION DR #2 TIME 2 PM DATE 2/5/75 SAMPLE 5
 PROCESS TEMP 556 OR BRINK SP 1.6 IN Hg
 BP ± SP 28.33 IN Hg

4 mm PROBE ⇒ .91 CFM ⇒ 1.67 ΔP₀ IN H₂O

1.67 ΔP₀ × 17.91 × 28.33 BP ± SP / 556 T_s = 1.51 ΔP₀

1.51 AVG ΔP FOR RUN

1.51 ΔP × 0.00559 × T_s 556 / 28.33 BP ± SP =

1.67 ΔP₀ ⇒ .81 CFM × 54 SAMPLE TIME =

43.74 ft³ COLLECTED × 17.91 × 30.24 BP + ΔP₀ / 13.1 / T_s 556

41.85 SCF COLLECTED

| | CYCLONE + FILTER | IMPINGER | TOTAL |
|--------------------------------|------------------|----------|-------|
| | mg | mg | mg |
| AN | 27.9 | 0 | 27.9 |
| NH ₃ | 0 | 450 | 450 |
| HNO ₃ | | | |
| H ₂ SO ₄ | | | |

EMISSIONS:

$(27.9) \text{ Mg} \times 2.205 \times 10^{-6} \times 1515702 \text{ SCFH} = 2.23 \text{ lb}$
 $(41.85) \text{ SCF}$

| | | |
|--------------------------------|------|-------|
| AN | 2.23 | lb/HR |
| NH ₃ | 36 | lb/HR |
| HNO ₃ | | lb/HR |
| H ₂ SO ₄ | | lb/HR |

BRINK MIST SAMPLER DATA

LOCATION P1#2 TIME 3PM DATE 7/7 SAMPLE 3
 PROCESS TEMP 556 OR BRINK SP 1.6 IN Hg
 BP ± SP 28.33 IN Hg

$\frac{4}{1}$ mm PROBE \Rightarrow .81 CFM \Rightarrow 1.67 ΔP IN H₂O

$1.67 \Delta P \times 17.71 \times \frac{28.33 \text{ BP} \pm \text{SP}}{556 T_s} = 1.51 \text{ APIN}$

1.51 AVG AP FOR RUN

$1.51 \text{ AP} \times 0.00557 \times T_s \frac{556}{28.33 \text{ BP} \pm \text{SP}}$

$1.67 \text{ AP} \Rightarrow .81 \text{ CFM} \times 72 \text{ SAMPLE TIME}$

$58.32 \text{ L}^3 \text{ COLLECTED} \times 17.71 \times \frac{30.07 \text{ BP} \pm \Delta P / 13.6}{T_s} \frac{556}{55.8}$

55.8 SCF COLLECTED

| | CYCLONE + FILTER MG | IMPINGER MG | TOTAL MG |
|--------------------------------|------------------------|----------------|-------------|
| AN | 23.87 | 0 | 23.87 |
| NH ₃ | 0 | 1252 | 1252 |
| HNO ₃ | | | |
| H ₂ SO ₄ | | | |

EMISSIONS:

$(23.87) \text{ Mg} \times 2.205 \times 10^{-6} \times \frac{1519.700}{(55.8) \text{ SCF}} \text{ SCFH} = 1.43 \text{ lb}$

| | | |
|--------------------------------|------|-------|
| AN | 1.43 | lb/HR |
| NH ₃ | 75 | lb/HR |
| HNO ₃ | | lb/HR |
| H ₂ SO ₄ | | lb/HR |