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COST COMPARISON OF OCEAN SHIPMENT OF ANHYDROUS AMMONIA
AND SOLID UREA VERSUS SHIPMENT OF UREA-AMMONIA SOLUTION

by

Frank P. Achorn and Harold G. Walkup

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This study compares the costs of production and ocean shipment of solid urea and anhydrous ammonia with those for urea-ammonia solution. The objective is to determine the costs of making available to four destination countries solid urea and three grades of urea-ammonium phosphate materials.

The urea would be made available at destination points by direct shipment of finished product or by decomposition and concentration of the urea-ammonia solution to solid urea and ammonia. The urea-ammonium phosphates would be produced in destination countries from solid urea, ammonia, and superphosphoric acid, or from urea-ammonia solution and superphosphoric acid.

The Gulf Coast area of the United States was selected as the area for production of nitrogen-containing primary materials considered in the cost analysis. These materials consist of solid urea (45 percent N), anhydrous ammonia (82 percent N), and urea-ammonia solution (33 percent N). The production of wet-process superphosphoric acid (70 percent P_2O_5) is assumed to be in the vicinity of Tampa, Florida.

It is assumed that the solid urea would be shipped in bulk in regular cargo vessels. The anhydrous ammonia shipping costs were estimated for shipment by refrigerated tankers at -28° F. and atmospheric pressure. The urea-ammonia solution selected is one having 5 psig. vapor pressure at 105° F., which can be considered a nonpressure solution for ocean shipment. The wet-process superphosphoric acid would be shipped in tankers equipped with stainless steel tanks.

Destination countries and ports to which primary products are assumed to be shipped are: Santos, Brazil; Bombay, India; Lagos, Nigeria; and Istanbul, Turkey. These were selected to provide a variety of conditions, such as length of haul, port facilities, and factory labor costs.

End products at destination ports are solid urea and urea-ammonium phosphate grades 34-17-0, 27-32-0, and 20-40-0. The three urea-ammonium phosphate grades can be produced by reacting urea-ammonia solution with superphosphoric acid. In the production of both the 34-17-0 and 27-32-0 grades, the ammonia and P_2O_5 are combined to form diammonium phosphate and supplemental urea is added to produce the desired N: P_2O_5 ratio. With the 20-40-0 grade, the ammonia and P_2O_5 combine to form monoammonium phosphate and no supplemental urea is required.

Cost Analysis Assumptions

The cost analysis is based on engineering cost estimates for modern plants of assumed capacities. Storage, handling, and shipping costs for the different products were obtained from reliable sources. Grass roots plants were assumed.* These plants provide battery limits capacity plus off-site facilities. In most instances, off-site facilities were estimated to require about 40 percent of the investment costs in the associated battery limits plants. Because of the increased costs of constructing plants overseas, investment costs for plants in foreign countries were increased by a factor of 1.33 over those assumed for domestic plants. Estimated costs of foreign storage were increased

*Fertilizer manufacturing plants are designated battery limits plants if they include only essential equipment and buildings required to produce a designated product or products. Off-site facilities include the land on which the plant is located and such associated facilities as rail sidings, maintenance shops, product storage facilities, and administrative buildings. The total complex--battery limits plant plus off-site facilities--is designated as a grass roots plant.

by a factor of 1.5 over those estimated for domestic storage of the same construction and capacity. Hence, all costs associated with investment for a given facility are higher in the designated countries than in the United States.

Working capital for the plants was estimated to be equivalent to that required for 60 days of variable and semivariable costs (60 days supply of raw materials plus labor). Forty percent of the working capital costs was added for incidentals. The gross roots plant investment was used in calculating depreciation, local taxes, insurance, and return on investment. An interest charge of 7 percent was used in determining the cost of working capital.

Operating labor benefit costs include such items as vacation leave, shift differential, and unit work. Maintenance, which includes maintenance, labor, and overhead, was calculated to be 5 percent of plant investment per ton of production capacity. Storage, handling, and shipping costs for primary and finished products were obtained from shipping companies and commercial fertilizer producers. The costs for finished products in destination ports were calculated in a series of steps beginning with costs incurred in producing primary nitrogen and phosphorus products with appropriate storage, handling, and shipping costs added between successive stages in the various processes.

Cost Study Findings

The findings of this study indicate that it is more economical to ship solid urea to all the foreign countries considered than to ship urea-ammonia solution and convert it to solid urea and ammonia at its destination. However, for manufacturing the three grades of urea-ammonium phosphate considered in the analysis, it is more economical to ship and use urea-ammonia solution to the

extent possible in each case rather than to ship and use solid urea and anhydrous ammonia. The cost differences obtained are presented in the following excerpt from table 28.

Estimated Cost Advantage or Disadvantage in Dollars
Per Short Ton of Product in Destination Country Ports

<u>Port</u>	<u>Urea From Urea-Ammonia Solution Versus Solid Urea</u>	<u>34-17-0</u>	<u>27-32-0</u>	<u>20-40-0</u>
		<u>Using Superphosphoric Acid with Urea-Ammonia Solution Versus Anhydrous Ammonia and Solid Urea</u>		
Brazil	-0.92	1.37	3.00	1.68
Turkey	-3.99	0.92	2.09	1.00
India	-7.04	0.45	1.67	0.35
Nigeria	-2.57	1.20	2.63	5.31

Analysis of Costs

The analysis is developed and presented through a series of tables which include the cumulative costs at given stages of production and movement to destination countries. All quantities of product are presented in short tons (2,000 pounds). Tables pertaining to individual product cost estimates show estimated plant capacity, fixed investment required, and various categories of inputs, including quantity and price, as well as the assumption and resulting costs of variable, semivariable, and fixed cost items. Summary tables are presented to show cost comparisons at certain stages of production, shipment, and manufacturing considered in the analyses.

Table 1 shows the cost of manufacturing anhydrous ammonia in Louisiana, U.S.A. in a modern 1,000-ton-per-day plant using centrifugal compressors operated by steam turbines. The estimated investment cost is \$11 million for a battery limits plant and an additional \$4 million for off-site facilities and equipment.

With a depreciation rate of 10 percent and a return of 20 percent on investment, which was assumed for all plants in the study, the total estimated cost of manufacturing the anhydrous ammonia is \$29.47 per ton.

Table 2 presents the costs of producing urea as 83 percent urea solution. The investment cost for the 400-ton-per-day urea solution grass roots producing facility is \$4.9 million. Total cost of the solution is estimated to be \$35.64 per ton of urea in solution.

In the next step of the analysis, the cost of producing urea-ammonia solution (33 percent N) in the Gulf Coast area is presented in table 3. The cost of the manufacturing facility is estimated to be \$140,000 for a plant having a capacity of 1,067 tons per day. The cost of ammonia and urea solution used in this process is obtained from tables 1 and 2 respectively. Estimated cost per ton of urea-ammonia solution is \$19.87 at the Gulf Coast plant.

Table 4 presents estimated costs for producing solid urea at the same site where ammonia is produced (for which costs are estimated in table 1). The fixed investment in the 450-ton-per-day plant is estimated to be \$7.42 million. Total cost of solid urea production is estimated to be \$43.69 per ton.

The cost of producing wet-process phosphoric acid in Florida is presented in table 5. The fixed investment for the 600-ton-per-day plant is estimated to be \$16,539,000, which includes both battery limits and off-site facilities for the wet-process phosphoric acid plant. These off-site investment costs amount to 75 percent rather than the 40 percent usually estimated of that required for the battery limits plant because of the nature of this plant. It is assumed that the cost of concentrating 54-percent P_2O_5 wet-process phosphoric acid to 70-percent P_2O_5 acid is \$8 per ton of P_2O_5 . This cost estimate was obtained from commercial producers of wet-process superphosphoric acid. The total estimated cost of 70-percent P_2O_5 wet-process superphosphoric acid is \$100.55 per ton of P_2O_5 .

Table 6 presents costs of storing and handling anhydrous ammonia in the U.S., based on two shiploads of 12,000 tons each, or the equivalent of 24 days of production from the 1,000-ton-per-day plant. This 24,000 tons of storage is the refrigerated type in which a temperature of -28° F. is maintained at atmospheric pressure. The estimated investment in this facility is \$960,000, or \$40 per ton of storage capacity. Assuming an annual throughput of 330,000 tons (the total estimated annual output of a 1,000-ton-per-day plant operating 330 days per year) and various operating costs for the storage facility, storage cost per ton is estimated to be about \$1.54 for the U. S. Gulf Coast.

Table 7 presents storing and handling costs for anhydrous ammonia in the ports of four receiving countries. Costs incurred in handling and storage are about 50 percent higher per ton of throughput than for storage in the United States. This increase in cost occurs because of the higher investment required in foreign countries. Therefore, all costs based on investment costs are higher. Also, the cost of power is estimated to be 3 mills per kwh higher in destination countries. The capital investment is estimated to be \$1,440,000 for a 24,000-ton-capacity storage tank, which amounts to \$60 per ton of capacity. Overall storage costs per ton of product put through the facility amount to about \$2.14.

The cost of storing and handling urea-ammonia solution in the U.S. Gulf Coast area is presented in table 8. Investment in storage capacity, pumping equipment, and other items amounts to \$160,000, or about \$7 per ton of storage capacity. With an annual throughput of 352,110 tons (from the production estimate presented in table 2), the cost per ton of product for domestic storage and handling amounts to about 41 cents per ton.

Table 9 presents the estimated costs for foreign storage and handling of urea-ammonia solution. Overall costs for the foreign storage and handling of urea-ammonia solution are estimated to be about 50 cents per ton.

Table 10 shows storage and handling costs for urea on the Gulf Coast of the U.S. The capital investment for 24,000 tons of capacity is estimated to be \$300,000 or about \$12.50 per ton. Annual throughput is estimated to be 148,500 tons (based on the estimated output of the plant for which the cost estimate was developed in table 4). The estimated cost per ton of throughput for domestic handling and storage of urea amounts to about \$1.30.

Table 11 presents costs for foreign storage and handling of bulk urea. Estimated investment costs amount to \$450,000 for a storage capacity of 24,000 tons; costs per ton are estimated to be about \$19. Overall costs per ton of product put through the facility amount to \$1.67.

The costs of storing and handling wet-process superphosphoric acid produced in Florida are presented in table 12. Capital investment costs for a 24,000-ton storage facility are estimated to be \$569,800 or about \$24 per ton. Based on an annual throughput of 214,280 tons of 70-percent P_2O_5 acid, the cost per ton amounts to about \$1.35 per ton of P_2O_5 .

In table 13, the cost of foreign storage and handling of wet-process superphosphoric acid is presented. The capital investment cost for a 24,000-ton storage facility is estimated to be \$854,700 or nearly \$36 per ton. The cost per ton of acid for handling and storage based on a throughput of 214,280 tons, amounts to about \$1.83 per ton of P_2O_5 .

Table 14 is a summary of cost data obtained from estimates presented in previous tables, as well as ship-loading in domestic ports and unloading in foreign ports, for the four primary products considered: anhydrous ammonia,

urea, urea-ammonia solution, and wet-process superphosphoric acid. Thus, the last column in table 14 presents the costs per ton less insurance and freight of these four products in storage in foreign ports.

Table 15 presents a cost summary for the total delivered cost per ton of primary products and per unit of plant nutrients into storage in the four ports. Costs given in table 14 are used in this presentation, and appropriate freight costs are added. It is assumed that the solid urea would be shipped and handled in bulk. While little urea has been shipped in bulk overseas, other materials having about the same or higher hygroscopicity have been shipped overseas without difficulty. Also, it is common practice to ship and handle urea in bulk in this country. It was assumed further that urea would have the same ocean freight rate as bulk ammonium sulfate. Insurance costs are not included, since they appear not to alter the cost picture sufficiently to warrant their inclusion. However, they are presented in table 29 as a matter of information.

The cost of manufacturing urea from urea-ammonia solution in Santos, Brazil, is presented in table 16. A similar cost analysis is given for Istanbul, Turkey, in table 17; for Bombay, India, in table 18; and for Lagos, Nigeria, in table 19. A capital investment cost of \$3,114,000 is estimated for a 400-ton-per-day grass roots plant to produce prilled urea from urea-ammonia solution in each of these countries. This investment cost includes a decomposer, concentrator, prilling tower, cooler, screens, solid handling equipment, and off-sites. The annual production of urea was assumed to be 136,000 tons. Since anhydrous ammonia is a by-product when solid urea is manufactured from urea-ammonia solution, a credit for ammonia is given in each case, based on the cost of anhydrous ammonia delivered to and stored in each country as presented in table 15. The following costs per ton of solid urea manufactured from urea-ammonia solution were determined for each of the four ports: \$63.08 for Santos, Brazil; \$66.65 for Istanbul, Turkey; \$73.70 for Bombay, India; and \$65.23 for Lagos, Nigeria.

The cost of manufacturing urea-ammonium phosphates in the three grades considered (34-17-0, 27-32-0, and 20-40-0) from urea-ammonia solution and wet-process superphosphoric acid for Santos, Brazil, is presented in table 20. A similar cost analysis is presented for Istanbul, Turkey, in table 21; for Bombay, India, in table 22; and for Lagos, Nigeria, in table 23. A capital investment cost of \$3,090,000 is required for the 550-ton-per-day plant considered for each country. The capital investment for these plants is based on a 1,000-ton-per-day diammonium phosphate plant. This assumption is realistic because it assumes that the recirculation rate in the urea-ammonium phosphate plant will be 10 pounds of recycle per pound of product. This is compared to a 5-to-1 recirculation rate for a conventional diammonium phosphate plant. It was assumed that the annual production of any one or any combination of these products would be 187,000 tons. Costs per ton of each of the ammonium phosphate products produced from urea-ammonia solution and superphosphoric acid in each port considered are presented in tables 20 through 23.

Costs of manufacturing urea-ammonium phosphates from anhydrous ammonia, solid urea, and wet-process superphosphoric acid in destination countries are presented in tables 24 through 27. Since the recycle rate will be about 60 percent of that required for plants using urea-ammonia solution, plants for producing urea-ammonium phosphate from these materials should require a smaller investment cost than those which use urea-ammonia solution. The capital investment for these plants is based on that required for a 700-ton-per-day diammonium phosphate plant. The total investment in each grass roots plant of 550 tons of daily capacity is estimated to be \$2,606,000. The total cost of manufacturing per ton for each of the three products considered is presented in tables 24 through 27 for each of the four ports.

Table 28 presents a summary of all costs considered for urea and urea-ammonium phosphates on a per-ton of product basis in ports of the four destination countries chosen for the analysis. Data in this table compare costs using urea-ammonia solution with those for anhydrous ammonia and urea in the production of urea-ammonium phosphates. Also, costs of receiving solid urea versus its manufacture in developing countries from urea-ammonia solution can be compared. As a general rule, costs of manufacturing urea-ammonium phosphates from urea-ammonia solution and superphosphoric acid appear to be less than when these products are manufactured from solid urea, ammonia, and superphosphoric acid. However, the advantage of using the urea-ammonia solution declines as the shipment distance increases. For urea, there appears to be no advantage in manufacturing it from urea-ammonia solution in destination countries. Instead, it appears desirable to ship solid urea as a final product (not to be used in further manufacture) to all countries considered.

Table 29 presents the estimated insurance rates and costs incurred for full and partial coverage for all risk insurance on the primary products considered. These data were not used in the cost analysis, but are included as a matter of information.

Table 1

ESTIMATED COST OF MANUFACTURING ANHYDROUS AMMONIA^a

Plant location: Louisiana, U.S.A.

Plant capacity: 1,000 tons per day, 340-day year, 340,000 tons per year.

Fixed investments: Battery limits plant, \$11,000,000; off-sites, \$4,400,000;
working capital, \$1,189,000^b

<u>Variable Costs</u>	<u>Quantity Per Ton^b</u>	<u>Dollar Per Unit</u>	<u>Dollar Per Ton</u>
Natural gas	34.2 MCF	0.25	8.55
Power	5 kwh	0.007	0.04
Cooling water	67.2 M gal.	0.02 ^b	1.34
Boiler water	0.48 M gal.	0.25 ^b	0.12
Catalyst and chemicals			0.58
Operating supplies			0.35
Loss	0.01	28.00	<u>0.28</u>
Subtotal			11.26
<u>Semivariable Costs</u>			
Operating labor (6 men per shift plus superintendent) 0.15 man-hour, 4.00 per man-hour ^c			0.60
Maintenance (5 percent of investment) ^d			2.26
Labor overhead (30 percent of operating labor and superintendent)			<u>0.18</u>
Subtotal			3.04

Table 1
(continued)

<u>Fixed Costs</u>	<u>Dollar Per Ton</u>
Plant overhead (70 percent of operating labor and supervision)	0.42
Depreciation (10 percent of investment per year) ^d	4.53
Local taxes and insurance (2 percent of investment per year) ^d	0.91
Interest on working capital (7 percent)	<u>0.25</u>
Subtotal	6.11
<u>Total Manufacturing Cost</u>	20.41
<u>Cost Item</u>	
Return on investment and administrative expense (20 percent of investment per year) ^d	9.06
<u>Total Cost per Short Ton</u>	29.47
<u>Total Cost per Metric Ton</u>	32.42

- a. Process: natural gas desulfurization, high-pressure reforming, CO₂ removal by M.E.A., methanation, compression, and ammonia synthesis using centrifugal compressors and steam turbines.
- b. Capital cost for battery limits and utility data obtained from reprint of paper, "Aspects of Large-Scale Ammonia Production," by L. C. Axelrod and T. E. O'Hare, presented at U. N. Inter-Regional Seminar on the Production of Fertilizer, August 24 through September 13, 1965. Cost for off-sites, preoperating expense, and contingencies from paper, "Questions and Answers on Today's Ammonia Plants," June 21, 1965, Chemical Engineering. Working capital, 60 days variable plus semi-variable cost, plus 40 percent.
- c. Includes benefits.
- d. On battery limits plant plus off-sites.

Table 2

ESTIMATED COST OF MANUFACTURE OF UREA SOLUTION, BASED ON 100 PERCENT UREA^a

Plant location: U. S. Gulf Coast

Plant capacity: 400 tons per day of 100-percent urea, 340-day year,
136,000 tons per year of 100-percent urea.Fixed investments: Battery limits plant, \$3,500,000; off-sites, \$1,400,000;
working capital, \$791,000^b

<u>Variable Costs</u>	<u>Quantity Per Ton</u>	<u>Dollar Per Unit</u>	<u>Dollar Per Ton</u>
Ammonia	0.58 T	29.47	17.09
Carbon dioxide	0.75 T	-	-
Oil	3.0 gals.	0.20	0.60
Power	151 kWh	0.007	1.06
Steam	2.2 M lbs.	0.45	0.99
Water	20.0 M gals.	0.02	0.40
Operating supplies			0.20
Product loss	0.01	36.00	<u>0.36</u>
Subtotal			20.70
<u>Semivariable Costs</u>			
Operating labor (5 men per shift) (plus 1/2 foreman) 0.15 man-hour, 4.00 per man-hour ^c			0.60
Maintenance (5 percent of investment per year)			1.80
Labor overhead (30 percent operating labor and supervision)			<u>0.18</u>
Subtotal			2.58

Table 2
(continued)

<u>Fixed Costs</u>	<u>Dollar Per Ton</u>
Plant overhead (70 percent of operating labor and supervision)	0.42
Depreciation (10 percent of investment per year) ^d	3.60
Local taxes and insurance (2 percent of investment per year) ^d	0.72
Interest on working capital (7 percent)	<u>0.41</u>
Subtotal	5.15
<u>Total Manufacturing Cost</u>	28.43
<u>Cost Item</u>	
Return on investment and administrative expense (20 percent of investment per year) ^d	7.21
<u>Total Cost per Short Ton</u>	35.64
<u>Total Cost per Metric Ton</u>	39.24

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- a. 83-percent solution and total recycle.
 - b. From cost curves supplied by Girdler Corporation for battery limits plant. Forty percent of battery limits investment for off-sites. Working capital assumed as 60 days of variable and semivariable costs plus 40 percent.
 - c. Includes benefits.
 - d. On battery limits plant plus off-sites.

Table 3

ESTIMATED COST OF MANUFACTURING UREA-AMMONIA SOLUTION33 PERCENT N (19-0-37.5)^a

Plant location: U. S. Gulf Coast

Plant capacity: 1,067 tons per day^b, 340-day year, 362,780 tons per year.Fixed investments: Battery limits plant, \$100,000; off-sites, \$40,000;
no working capital required.

<u>Variable Costs</u>	<u>Quantity Per Ton</u>	<u>Dollar Per Unit</u>	<u>Dollar Per Ton</u>
Urea solution (100-percent urea)	0.375	35.64	13.37
Ammonia	0.190	29.47	5.60
Water	0.104 M gals.	0.02	-
Power	4.00 kwh	0.007	0.03
Operating supplies			0.04
Product loss	0.01	20.00	<u>0.20</u>
Subtotal			19.24
<u>Semivariable Costs</u>			
Operating labor (2 men per shift) (plus 1/2 foreman) 0.06 man-hour, 4.00 per man-hour			0.24
Maintenance (5 percent of investment)			0.02
Labor overhead (30 percent of operating labor)			<u>0.07</u>
Subtotal			0.33
<u>Fixed Costs</u>			
Plant overhead (70 percent of operating labor)			0.17
Depreciation (10 percent of investment per year) ^d			0.04
Local taxes and insurance (2 percent of investment per year) ^d			<u>0.01</u>
Subtotal			0.22

Table 3
(continued)

	<u>Dollar Per Ton</u>
<u>Total Manufacturing Cost</u>	19.79
 <u>Cost Item</u>	
Return on investment and administrative expense (20 percent)	0.08
 <u>Total Cost per Short Ton</u>	 19.87
<u>Total Cost per Metric Ton</u>	21.86

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- a. Vapor pressure at 5 psig. at 105° F. Parenthetical notation indicates percentages of ammonia, ammonium nitrate, and urea, respectively.
- b. Based on 400 tons of urea per day.
- c. From a commercial company's operating data.
- d. Calculated on battery limits plant plus off-sites.

Table 4

ESTIMATED COST OF MANUFACTURE OF PRILLED UREA (45 PERCENT N)

Plant location: Louisiana, U.S.A.

Plant capacity: 450 tons per day, 340-day year, 153,000 tons per year.

Fixed investments: Battery limits plant, \$5,300,000; off-sites, \$2,120,000; working capital, \$1,020,000^a.

<u>Variable Costs</u>	<u>Quantity Per Ton</u>	<u>Dollar Per Unit</u>	<u>Dollar Per Ton</u>
Ammonia	0.58 T	29.47	17.09
Carbon dioxide	0.75 T	-	-
Oil	3.0 gals.	0.20	0.60
Power	190 kwh	0.007	1.33
Fuel gas	9.7 MCF	0.25	2.43
Water	17.0 M gals.	0.02	0.34
Clay	0.02 T	50.00	1.00
Operating supplies ^b			0.20
Product loss	0.01		
Subtotal			22.99
<u>Semivariable Costs</u>			
Operating labor (5 men per shift and 1 superintendent) 0.284 man-hour, 4.00 per man-hour ^c			1.14
Maintenance (5 percent of investment)			2.43
Labor overhead (30 percent of labor and supervision)			<u>0.34</u>
Subtotal			3.91

Table 4
(continued)

<u>Fixed Costs</u>	<u>Dollar Per Ton</u>
Plant overhead (70 percent of operating labor and supervision)	0.80
Depreciation (10 percent of investment per year) ^d	4.85
Local taxes and insurance (2 percent investment per year) ^d	0.97
Interest on working capital (7 percent)	<u>0.47</u>
Subtotal	7.09
<u>Total Manufacturing Cost</u>	33.99
<u>Cost Item</u>	
Return on investment and administrative expense (20 percent of investment per year) ^d	9.70
<u>Total Cost per Short Ton</u>	43.69
<u>Total Cost per Metric Ton</u>	48.06

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- a. Battery limits plant cost information supplied by Mr. M. G. Verghese, Inter-Regional Advisor of the Technological Division, Center for International Development, United Nations. Off-sites, 40 percent of battery limits plant. Working capital, 60 days of variable plus semivariable costs plus 40 percent.
- b. Operating data from a commercial company.
- c. Includes benefits.
- d. Calculated using battery limits plant plus off-sites.

Table 5

ESTIMATED COST OF MANUFACTURING WET-PROCESS PHOSPHORIC ACID (70 PERCENT P₂O₅)

Plant location: Florida, U.S.A.

Plant capacity: 600 tons P₂O₅ per day, 340-day year, 204,000 tons P₂O₅ annually.Fixed investments: Battery limits plant, \$9,429,000; off-sites, \$7,110,000; working capital, \$3,250,000^a

<u>Variable Costs</u>	<u>Quantity Per Ton</u>	<u>Dollar Per Unit</u>	<u>Dollar Per Ton (P₂O₅)</u>
Phosphate rock 72 B.P.L.	3.27 ^b	7.90 ^c	25.83
Sulfur	0.93 ^b	26.00 ^d	24.18
Cooling water	27.0 M gals.	0.02	0.54
Boiler feedwater	1 M gals.	0.40	0.40
Power	327 kwh	0.009	2.94
Supplies and chemicals			1.71
Product loss	0.01	93.00	<u>0.93</u>
Subtotal			56.53
<u>Semivariable Costs</u>			
Salaries and wages 0.614 ^c man-hour, 4.00 per man-hour ^f			2.46
Maintenance (5 percent per year of investment) ^a			4.05
Labor overhead (30 percent of salaries and wages)			<u>0.74</u>
Subtotal			7.25
<u>Fixed Costs</u>			
Plant overhead (70 percent of salaries and wages)			1.72
Depreciation (10 percent per year) ^g			8.10
Interest on working capital (7 percent) ^h			1.12
Taxes and insurance (2 percent plant investment) ^g			<u>1.62</u>
Subtotal			12.56

Table 5
(continued)

	<u>Dollar Per Ton (P₂O₅)</u>
<u>Total Manufacturing Cost</u>	76.34
<u>Cost Item</u>	
Return on investment (20 percent)	16.21
<u>Total cost per short ton</u>	92.55
<u>Conversion to Superphosphoric Acid</u>	
Concentration (\$8 per ton of P ₂ O ₅ for 54 percent P ₂ O ₅ to 70 percent P ₂ O ₅) ¹	8.00
Cost (70 percent P ₂ O ₅ superphosphoric acid wet-process)	100.55
<u>Cost Per Metric Ton</u>	110.61
Cost per Ton of Superphosphoric Acid	\$70.39

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- a. Capital investments from paper, "Economic Outlook for Elemental Phosphorus," in Fertilizer Manufacture by T. P. Hignett and M. M. Striplin, to be presented at the 1967 meeting of the American Institute of Chemical Engineers.
 - b. Assume 92-percent recovery H₂SO₄:P₂O₅ wt. ratio = 2.56.
 - c. Quoted price commercial producer. 72 B.P.L. instead of 68 B.P.L. because superphosphoric acid produced.
 - d. Oil, Paint and Drug Reporter, current price.
 - e. Includes 10 men per shift, plus 16 on day shift.
 - f. Includes benefits.
 - g. On battery limits plant, plus off-sites.
 - h. Sixty days of variable and semivariable cost, plus 40 percent.
 - i. Supplied by commercial producers.

Table 6

U. S. COST FOR STORING AND HANDLING OF ANHYDROUS AMMONIAStorage capacity: 24,000 tons^aCapital investment: \$960,000^b

Annual throughput: 330,000 tons

Annual Operating Costs

Power (9,900,000 kwh at \$0.007 per kwh) \$ 69,300.00

Cooling water (22.11 MM gals. at \$0.03 per M gals.) 663.00

Steam (52.8 MM lbs. at \$0.41 per M lbs.) 21,648.00

Labor and supervision^c 39,600.00

Overhead (100 percent labor and supervision) 39,600.00

Maintenance (3 percent of investment) 28,800.00

Taxes and insurance (2 percent of investment) 19,200.00

Depreciation (10 percent of investment) 96,000.00

Return on investment (20 percent) 192,000.00

Total \$506,811.00

Cost per Short Ton of Product \$ 1.536Cost per Metric Ton of Product 1.693

-
- a. Approximately equivalent to two shiploads of 1,200 short tons each.
- b. Based on information supplied by the United Nations' staff regarding refrigerated storage of anhydrous ammonia at -28° F. at atmospheric pressure.
- c. Based on the requirement of one laborer at \$2 per hour and one supervisor at \$3 per hour on each shift. 330-day year. Assume 10 days of storage associated with production facility.

Table 7

FOREIGN COST FOR STORING AND HANDLING OF ANHYDROUS AMMONIAStorage capacity: 24,000 tons^aCapital investment: \$1,440,000^b

Annual throughput: 330,000 tons

Annual Operating Costs

Power (9,900,000 kwh at \$0.010 per kwh)	\$ 99,000.00
Cooling water (22.11 MM gals. at \$0.03 per M gals.)	663.00
Steam (52.8 MM lbs. at \$0.41 per M gals.)	21,648.00
Labor and supervision ^c	39,600.00
Overhead (100 percent of labor and supervision)	39,600.00
Maintenance (3 percent of investment)	43,200.00
Taxes and insurance (2 percent of investment)	28,800.00
Depreciation (10 percent of investment)	144,000.00
Return on investment (20 percent of investment)	<u>288,000.00</u>
Total	\$704,511.00
<u>Cost per Short Ton of Product</u>	\$ 2.135
<u>Cost per Metric Ton of Product</u>	2.353

-
- a. Approximately equivalent to two shiploads of 1,200 short tons each.
- b. Equivalent to 1.5 times the U. S. cost.
- c. Assume total labor cost about same as U. S. cost. The individual labor cost is less, but more laborers are used. See table 9 for U. S. labor cost. 330-day year. Assume 10 days storage associated with production facility.

Table 8

U. S. COST OF STORING AND HANDLING UREA-AMMONIA SOLUTION33 PERCENT N (19-0-37.5)^a

Storage capacity: 24,000 tons

Capital investment: \$160,000^b

Annual throughput: 352,110 tons

Annual Operating Costs

Power (1,155,000 kwh at \$0.007 per kwh)	\$ 8,085.00
Labor and supervision ^c	39,600.00
Overhead (100 percent of labor and supervision)	39,600.00
Maintenance (3 percent of investment)	4,800.00
Taxes and insurance (2 percent of investment)	3,200.00
Depreciation (10 percent of investment)	16,000.00
Return on investment (20 percent)	<u>32,000.00</u>
Total	\$143,285.00
<u>Cost per Short Ton of Product</u>	\$ 0.407
<u>Cost per Metric Ton of Product</u>	0.449

- a. Vapor pressure of solution of 5 paig. at 105° F. Parenthetical notation indicates the percentage of ammonia, ammonium nitrate, and urea respectively.
- b. Based on the assumption that the solution weighs nine pounds per gallon. A commercial supplier's one-million-gallon solution tank costs \$30,000 or 3 cents per gallon. Storage capacity of 5,333,333 gallons is required.
- c. Based on the requirement of one laborer at \$2 per hour and one supervisor at \$3 per hour on each shift. 330-day year. Assume 10 days storage associated with production facility.

Table 9

FOREIGN COST OF STORING AND HANDLING OF UREA-AMMONIA SOLUTION33 PERCENT N (19-0-37.5)^a

Storage capacity: 24,000 tons

Capital investment: \$240,000^b

Annual throughput: 352,110 tons

Annual Operating Costs

Power (1,155,000 kwh at \$0.010 per kwh)	\$ 11,550.00
Labor and supervision ^c	39,600.00
Overhead (100 percent of labor and supervision)	39,600.00
Maintenance (3 percent of investment)	7,200.00
Taxes and insurance (2 percent of investment)	4,800.00
Depreciation (10 percent of investment)	24,000.00
Return on investment (20 percent)	<u>48,000.00</u>
Total	\$174,750.00
<u>Cost per Short Ton of Product</u>	\$ 0.497
<u>Cost per Metric Ton of Product</u>	0.548

- a. Vapor pressure of solution of 5 psig. at 105° F. Parenthetical notation indicates the percentage of ammonia, ammonium nitrate, and urea respectively.
- b. Equivalent to 1.5 times the U. S. cost. See table 8 for basic U. S. cost.
- c. Assume labor cost same as U. S. The individual labor rate is less, but more people are used. See footnote c, table 7, basis of U. S. labor cost. 330-day year. Assume 10 days storage associated with production facility.

Table 10

U. S. STORING AND HANDLING COSTS FOR UREA FROM
450-TON-PER-DAY PLANT OPERATING 330 DAYS ANNUALLY

Storage capacity: 24,000 tons^a

Capital investment: \$300,000

Annual throughput: 148,500 tons

Annual Operating Costs

Power (1,178,100 kwh at \$0.007 per kwh)	\$ 8,246.70
Labor and supervision ^b	39,600.00
Overhead (100 percent of labor and supervision)	39,600.00
Maintenance (3 percent of investment)	9,000.00
Taxes and insurance (2 percent of investment)	6,000.00
Depreciation (10 percent of investment)	30,000.00
Return on investment (20 percent)	<u>60,000.00</u>
Total	\$192,446.70

<u>Cost per Short Ton of Product</u>	\$ 1.296
<u>Cost per Metric Ton of Product</u>	1.428

a. Approximately equivalent to two shiploads of ^{12,000}~~1,200~~ short tons each.

b. Assume one laborer at \$2 per hour and another at \$3 per hour. Assume 10 days storage associated with production facility.

Table 11

FOREIGN STORING AND HANDLING COSTS FOR UREA IMPORTING FROM
450-TON-PER-DAY PLANT OPERATING 330 DAYS ANNUALLY

Storage capacity: 24,000 tons^a

Capital investment: \$450,000^b

Annual throughput: 148,500 tons

Annual Operating Costs

Power (1,178,100 kwh at \$0.010 kwh)	\$ 11,781.00
Labor and supervision ^c	39,600.00
Overhead (100 percent of labor and supervision)	39,600.00
Maintenance (3 percent of investment)	13,500.00
Taxes and insurance (2 percent of investment)	9,000.00
Depreciation (10 percent of investment)	45,000.00
Return on investment (20 percent)	<u>90,000.00</u>
Total	\$248,481.00
<u>Cost per Short Ton of Product</u>	\$ 1.673
<u>Cost per Metric Ton of Product</u>	1.844

-
- a. Approximately equivalent to two shiploads of ^{12,000}~~1,200~~ short tons each.
- b. 1.5 times U. S. investment cost. See table 10 for U. S. cost.
- c. Assume labor cost same as U. S. Individual labor wage rate is less, but more laborers are used. See footnote b, table 5, for basis of U. S. cost of labor. Also assume 10 days storage associated with production facility.

Table 12

U. S. COST OF STORING AND HANDLING SUPERPHOSPHORIC ACID (70 PERCENT P₂O₅)

Storage capacity: 24,000 tons

Capital investment: \$569,800^{a,b}Annual throughput: 150,000 tons of P₂O₅ equivalent to 214,280 tons of
70 percent P₂O₅Annual Operating Costs

Power (1,200,000 kwh at \$0.009 per kwh)	\$ 10,800.00
Labor and supervision ^c	39,600.00
Overhead (100 percent of labor and supervision)	39,600.00
Maintenance (3 percent of investment)	17,094.00
Taxes and insurance (2 percent of investment)	11,396.00
Depreciation (10 percent of investment)	56,980.00
Return on investment (30 percent)	<u>113,960.00</u>
Total	\$289,430.00
<u>Cost per Short Ton</u>	\$ 1.351
<u>Cost per Metric Ton</u>	1.475

- a. 150 tons of superphosphoric acid storage cost \$20,000 projected to 24,000 tons by:

$$\left(\frac{24,000}{150}\right)^{0.66} \times \$20,000 = \$569,800$$

Reference for 150 tons of storage is a commercial company's actual construction record. Basis for calculation from Fundamentals of Cost in Chemical Industry by Bauman.

- b. Tank well insulated with rigid urethane foam insulation. Acid added to tank at a temperature well above 200° F. It should not cool below 150° F. prior to shipment, because hot acid is continuously added to tank.
- c. Based on requirement of one laborer at \$2 per hour and one supervisor at \$3 per hour. 330-day year. Assume 10 days storage associated with production facility.

Table 13

FOREIGN COST OF STORING AND HANDLING SUPERPHOSPHORIC ACID

Storage capacity: 24,000 tons

Capital investment: \$854,700^{a,b}Annual throughput: 150,000 tons of P₂O₅ equivalent to 214,280 tons of
70 percent P₂O₅Annual Operating Costs

Power (1,200,000 kwh at \$0.010 per kwh)	\$ 12,000.00
Labor and supervision ^c	39,600.00
Overhead (100 percent of labor and supervision)	39,600.00
Maintenance (3 percent of investment)	25,640.00
Taxes and insurance (2 percent of investment)	17,094.00
Depreciation (10 percent of investment)	85,470.00
Return on investment (20 percent)	<u>170,940.00</u>
Total	\$390,344.00
<u>Cost Per Short Ton</u>	\$ 1.822
<u>Cost Per Metric Ton</u>	2.008

a. 1.5 times U. S. investment cost.

b. See footnotes a and b of table 12.

c. Assume total labor cost same as in U. S. Individual labor wage rate is lower, but more laborers are used. 330-day year. Assume 10 days storage associated with production facility.

Table 14

SUMMARY OF PRODUCTION, STORAGE, LOADING, UNLOADING, AND RESTORING
OF AMMONIA, UREA, UREA-AMMONIA SOLUTION, AND WET-PROCESS SUPERPHOSPHORIC ACID

<u>Material</u>	<u>Production Cost \$/Ton</u>	<u>U. S. Storage Cost \$/Ton</u>	<u>U. S. Loading Cost \$/Ton</u>	<u>Foreign Unloading Cost^a \$/Ton</u>	<u>Foreign Storage Cost \$/Ton</u>	<u>Total Production and Handling Cost, Excluding Freight \$/Ton</u>
Ammonia	29.47	1.54	1.50 ^b	1.50	2.14	36.15
Urea	43.69	1.30	3.00 ^c	3.00	1.67	52.66
Urea-ammonia solution	19.87	0.41	1.50 ^b	1.50	0.50	23.78
Wet-process superphosphoric acid	70.39	1.35	1.50 ^b	1.50	1.82	76.56

- a. Assume same total cost as for the U. S. Their hourly wage rate is less, but more laborers are used.
- b. Cost of unloading liquids based on data from barge and steamship companies.
- c. Supplied by a commercial producer of urea.

Table 15

SUMMARY TOTAL DELIVERED COST TO UREA-AMMONIUM PHOSPHATE PLANTS
IN THE PORT AREAS OF DESIGNATED DEVELOPING COUNTRIES

<u>Delivery Point</u>	<u>Material</u>	<u>Total Production and Handling Cost^a Excluding Freight \$/Ton</u>	<u>Overseas Freight Rate \$/Ton</u>	<u>Total Delivered Cost \$/Ton</u>	<u>Total Delivered Cost \$/Unit of Plant Food</u>
Santos, Brazil	Ammonia	36.15	16.50 ^b	52.65	0.64
	Solid urea	52.66	9.50 ^c	62.16	1.38
	Urea-ammonia solution	23.78	4.92 ^d	28.70	0.87
	Superphosphoric acid	76.55	9.18 ^e	85.73	1.23
	Conditioner	46.00	9.50	55.50	
Istanbul, Turkey	Ammonia	36.15	14.50 ^f	50.65	0.62
	Solid urea	52.66	10.00 ^c	62.66	1.39
	Urea-ammonia solution	23.78	5.84 ^d	29.62	0.90
	Superphosphoric acid	76.55	10.94 ^e	87.49	1.25
	Conditioner	46.00	10.00	56.00	
Bombay, India	Ammonia	36.15	22.00 ^b	58.15	0.71
	Solid urea	52.66	14.00 ^c	66.66	1.48
	Urea-ammonia solution	23.78	9.85 ^d	33.63	1.02
	Superphosphoric acid	76.55	17.62 ^e	94.17	1.35
	Conditioner	46.00	14.00	60.00	
Lagos, Nigeria	Ammonia	36.15	15.00 ^g	51.15	0.62
	Solid urea	52.66	10.00 ^c	62.66	1.39
	Urea-ammonia solution	23.78	5.31 ^d	29.09	0.88
	Superphosphoric acid	76.55	9.92 ^e	86.47	1.24
	Conditioner	46.00	10.00	56.00	

a. From table 14.

b. Spot charter rate for 10,000 MT cargoes in refrigerated vessel from a commercial company.

c. The Journal of World Nitrogen published by the British Sulphur Corporation, Ltd., No. 40, March/April, 1966.

d. 17,000 long ton vessel. Information source: a commercial fertilizer exporting company.

e. 12,000 long ton vessel with stainless steel lined tank. Information source: a commercial fertilizer exporting company.

f. Assume same freight rate as North Greece Port.

g. Assume same freight rate as for Sweden. Nigeria and Sweden about equal distance from New Orleans.

Table 16

ESTIMATED COST OF UREA CONCENTRATION AND PRILLING WITH
UREA-AMMONIA SOLUTION, BRAZIL

Plant location: Santos, Brazil

Plant capacity: 400 tons per day urea, 340-day year, 136,000 tons per year of urea.

Fixed investments: Battery limits plant, \$2,394,000; off-sites, \$720,000; working capital, \$1,820,000^a

<u>Variable Costs</u>	<u>Quantity Per Ton</u>	<u>Dollar Per Unit</u>	<u>Dollar Per Ton</u>
Urea-ammonia solution, 33-percent N (19-0-37.5)	2.67 T	28.70	76.63
Power	39 kWh ^b	0.010	0.39
Fuel (naptha)	0.029 ^c	19.00 ^d	0.55
Clay conditioner	0.020 T	55.50	1.11
Supplies			0.10
Product loss	0.01	56.00	<u>0.56</u>
Subtotal			79.34
 <u>Semivariable Costs</u>			
Salaries and wages 0.22 man-hour, 2.30 per man-hour ^e			0.51
Maintenance (5 percent of investment per year) ^f			1.14
Labor overhead (30 percent of operating labor and supervision)			<u>0.15</u>
Subtotal			1.80
 <u>Fixed Costs</u>			
Plant overhead (70 percent operating labor and supervision)			0.36
Depreciation (10 percent of investment per year) ^f			2.29
Taxes and insurance (2 percent of investment per year) ^f			<u>0.46</u>
Subtotal			3.11

Table 16
(continued)

	Dollar Per Ton
<u>Total Manufacturing Cost</u>	84.25
Credit for 0.507 ton of NH ₃ produced (0.507 T x \$52.65) ^g	<u>26.69</u>
<u>Net Manufacturing Cost</u>	57.56
Return on investment (20 percent) ^f	4.58
Interest on working capital (7 percent)	<u>0.94</u>
<u>Total Cost per Short Ton</u>	63.08
<u>Total Cost per Metric Ton</u>	69.39

-
- a. Capital investment in the urea concentration and prilling battery limits plant = capital investment in the urea plant (\$5,300,000) - capital investment in the urea solution plant (\$3,500,000) = \$1,800,000. Since foreign investment is 1.33 times domestic investment, total capital investment = \$1,800,000 x 1.33 = \$2,394,000. Off-sites equal 40 percent battery limits U. S. plant. Working capital, 60 days of variable cost plus semivariable cost plus 40 percent (less credit for ammonia).
- b. Power for solid urea plant (table 4) minus power for solution plant (table 2).
- c. Naptha heat of combustion = 18,900 BTU per lb. 0.435 T or 870 lbs. of water must be evaporated per ton of urea $0.435 \times 2,000 = 870$ lbs. of water; therefore, naptha to evaporate this water, assuming a 20-percent heat loss, = $\frac{870 \times 1,000}{18,900 \times .80}$.
- d. World market price.
- e. Includes benefits.
- f. On battery limits plus off-sites.
- g. Delivered cost ammonia to Santos, table 15.

Table 17

ESTIMATED COST OF UREA CONCENTRATION AND PRILLINGWITH UREA-AMMONIA SOLUTION, TURKEY

Plant location: Istanbul, Turkey

Plant capacity: 400 tons per day urea, 340-day year, 136,000 tons per year.

Fixed investments: Battery limits plant, \$2,394,000; off-sites, \$720,000;
working capital, \$1,820,000^a.

<u>Variable Costs</u>	<u>Quantity Per Ton</u>	<u>Dollar Per Unit</u>	<u>Dollar Per Ton</u>
Urea-ammonia solution, 33-percent N (19-0-37.5)	2.67 T	29.62	79.09
Power	39 kwh ^b	0.010	0.39
Fuel	0.029 ^c	19.00 ^d	0.55
Conditioner	0.020	56.00	1.12
Operating supplies			0.10
Product loss	0.01	65.00	<u>0.65</u>
Subtotal			81.90
<u>Semivariable Costs</u>			
Salaries and wages 0.22 man-hour, 2.30 per man-hour ^e			0.51
Maintenance (5 percent of investment per year) ^f			1.14
Labor overhead (30 percent operating labor and supervision)			<u>0.15</u>
Subtotal			1.80
<u>Fixed Costs</u>			
Plant overhead (70 percent of operating labor and supervision)			0.36
Depreciation (10 percent of investment per year) ^f			2.29
Taxes and insurance (2 percent investment per year) ^f			<u>0.46</u>
Subtotal			3.11

Table 17
(continued)

	Dollar Per Ton
<u>Total Manufacturing Cost</u>	86.81
Credit for 0.507 T of NH ₃ produced (0.507 T x \$50.65) ^g	<u>25.68</u>
<u>Net Manufacturing Cost</u>	61.13
Return on investment (20 percent of investment per year) ^f	4.58
Interest on working capital (7 percent)	<u>0.94</u>
<u>Total Cost per Short Ton</u>	66.65
<u>Total Cost per Metric Ton</u>	73.32

-
- a. Capital investment in the urea concentration and prilling battery limits plant = capital investment in the urea plant (\$5,300,000) - capital investment in the urea solution plant (\$3,500,000) = \$1,800,000. Since foreign investment is 1.33 times domestic investment, total capital investment = \$1,800,000 x 1.33 = \$2,394,000. Off-sites equal 40 percent battery limits U. S. plant. Working capital, 60 days of variable cost plus semivariable cost plus 40 percent.
- b. Power for solid urea plant (table 4) minus power for solution plant (table 2).
- c. Naptha heat of combustion = 18,900 BTU per lb. 0.435 T or 870 lbs. of water must be evaporated per ton of urea 0.435 x 2,000 = 870 lbs. of water; therefore, naptha to evaporate this water, assuming a 20-percent heat loss, = $\frac{870 \times 1,000}{18,900 \times .80}$.
- d. World market price.
- e. Includes benefits.
- f. On battery limits plus off-sites.
- g. Delivered Istanbul, Turkey.

Table 18

ESTIMATED COST OF UREA CONCENTRATION AND PRILLINGWITH UREA-AMMONIA SOLUTION, INDIA

Plant location: Bombay, India

Plant capacity: 400 tons per day urea, 330-day year, 132,000 tons per year of urea.

Fixed investments: Battery limits plant, \$2,394,000; off-sites, \$720,000; working capital, \$1,820,000.^a

<u>Variable Costs</u>	<u>Quantity Per Ton</u>	<u>Dollar Per Unit</u>	<u>Dollar Per Ton</u>
Urea-ammonia solution, 33-percent N (19-0-37.5)	2.67 T	33.63	89.79
Power	39 kwh ^b	0.010	0.39
Fuel (naptha)	0.29 ^c	19.00 ^d	0.55
Clay conditioner	0.020 T	60.00	1.20
Operating supplies			0.10
Product loss	0.01	72.00	<u>0.72</u>
Subtotal			92.75
<u>Semivariable Costs</u>			
Salaries and wages 0.22 man-hour, 2.30 man-hour ^e			0.51
Maintenance (5 percent of investment per year) ^f			1.14
Labor overhead (30 percent of operating labor and supervision)			<u>0.15</u>
Subtotal			1.80
<u>Fixed Costs</u>			
Plant overhead (70 percent of operating labor and supervision)			0.36
Depreciation (10 percent of investment per year) ^f			2.29
Taxes and insurance (2 percent of investment per year) ^f			<u>0.46</u>
Subtotal			3.11

Table 18
(continued)

	<u>Dollar Per Ton</u>
<u>Total Manufacturing Cost</u>	97.66
Credit for 0.507 tons of NH ₃ produced (0.507 T x \$58.15) ^E	<u>29.48</u>
<u>Net Manufacturing Cost</u>	68.18
Return on investment (20 percent of investment per year) ^f	4.58
Interest on working capital (7 percent)	<u>0.94</u>
<u>Total Cost per Short Ton</u>	73.70
<u>Total Cost per Metric Ton</u>	81.07

- a. Capital investment in the urea concentration and prilling battery limits plant = capital investment in the urea plant (\$5,300,000) - capital investment in the urea solution plant (\$3,500,000) = \$1,800,000. Since foreign investment is 1.33 times domestic investment, total capital investment = \$1,800,000 x 1.33 = \$2,394,000. Off-sites equal 40 percent battery limits U. S. plant. Working capital, 60 days of variable cost plus semivariable cost plus 40 percent.
- b. Power for solid urea plant (table 4) minus power for solution plant (table 2).
- c. Naptha heat of combustion = 18,900 BTU per lb. 0.435 T or 870 lbs. of water must be evaporated per ton of urea 0.435 x 2,000 = 870 lbs. of water; therefore, naptha to evaporate this water, assuming a 20-percent heat loss,

$$= \frac{870 \times 1,000}{18,900 \times .80}$$
- d. World market price.
- e. Includes benefits.
- f. On battery limits plus off-sites.
- g. Delivered to Bombay, India.

Table 19

ESTIMATED COST OF UREA CONCENTRATION AND PRILLING WITH
UREA-AMMONIA SOLUTION, NIGERIA

Plant location: Lagos, Nigeria

Plant capacity: 400 tons per day, 330-day year, 132,000 tons per year.

Fixed investments: Battery limits plant, \$2,394,000^a; off-sites, \$720,000;
working capital, \$1,820,000.

<u>Variable Costs</u>	<u>Quantity Per Ton</u>	<u>Dollar Per Unit</u>	<u>Dollar Per Ton</u>
Urea-ammonia solution, 33-percent N (19-0-37.5)	2.67 T	29.09	77.67
Power	39 kwh ^b	0.025	0.98
Fuel (natural gas)	0.870 mcf ^c	0.28 ^d	0.24
Clay conditioner	0.020	56.00	1.12
Supplies			0.10
Product loss	0.01	62.00	<u>0.62</u>
Subtotal			80.73
 <u>Semivariable Costs</u>			
Salaries and wages 0.22 man-hour, 2.30 per man-hour ^e			0.51
Maintenance (5 percent of investment per year)			1.14
Labor overhead (30 percent of operating labor and supervision)			<u>0.15</u>
Subtotal			1.80
 <u>Fixed Costs</u>			
Plant overhead (70 percent of operating labor and supervision)			0.36
Depreciation (10 percent of investment per year) ^f			2.29
Taxes and insurance (2 percent investment per year) ^f			<u>0.46</u>
Subtotal			3.11

Table 19
(continued)

	<u>Dollar Per Ton</u>
<u>Total Manufacturing Cost</u>	85.64
Credit for 0.507 tons NH ₃ produced (0.507 T x \$51.15) ^g	<u>25.93</u>
<u>Net Manufacturing Cost</u>	59.71
Return on investment (20 percent of investment per year) ^f	4.58
Interest on working capital (7 percent)	<u>0.94</u>
<u>Total Cost per Short Ton</u>	65.23
<u>Total Cost per Metric Ton</u>	71.75

-
- a. Capital investment in the urea concentration and prilling plant = capital investment in the urea plant (\$5,300,000) - capital investment in the urea solution plant (\$3,500,000) = \$1,800,000. Since foreign investment is 1.33 times domestic investment, total capital investment = \$1,800,000 x 1.33 = \$2,394,000.
- b. Power for solid urea plant (table 4) minus power for solution plant (table 2).
- c. Natural gas heat combustion 1,000,000 cu. ft. of gas required = $\frac{435 \times 2 \times 1}{1}$ = 870 cu. ft. gas per ton.
- d. An Evaluation of Mineral Fertilizer Manufacturing Possibilities in Eastern Nigeria. Report to the Government of Eastern Nigeria, Arthur D. Little, Inc., December 1963.
- e. Includes benefits.
- f. On battery limits plus off-sites.
- g. Delivered cost ammonia to Lagos, Nigeria.

Table 20

ESTIMATED PRODUCTION COST OF UREA-AMMONIUM PHOSPHATE
FROM UREA-AMMONIA SOLUTION AND SUPERPHOSPHORIC ACID, BRAZIL

Plant location: Santos, Brazil

Plant capacity: 550 tons per day, 340-day year, 187,000 tons per year.

Fixed investments: Battery limits plant, \$2,210,000; off-sites, \$880,000; working capital, \$3,000,000.^a

Variable Costs	34-17-0 ^b			27-32-0 ^b			20-40-0 ^c		
	Quantity/Ton	\$/Unit	\$/Ton	Quantity/Ton	\$/Unit	\$/Ton	Quantity/Ton	\$/Unit	\$/Ton
Superphosphoric acid (70-percent P ₂ O ₅)	0.248 T	85.73	21.26	0.467 T	85.73	40.04	0.583 T	85.73	49.98
Urea-ammonia solution (33-percent N)	0.440 T	28.70	12.63	0.835 T	28.70	23.96	0.618 T	28.70	17.74
Urea (45-percent N)	0.449 T	62.16	27.91	-	-	-	-	-	-
Conditioner	0.025 T ^d	55.50	1.39	0.020 T ^e	55.50	1.11	0.020 T ^e	55.50	1.11
Water	0.60 M gals.	0.02	0.01	0.60 M gals.	0.01	0.02	0.60 M gals.	0.01	0.02
Power	20 kwh	0.010	0.20	20 kwh	0.010	0.20	20 kwh	0.010	0.20
Fuel oil	1.1x 10 ⁶ BTU	0.58	0.63	1.2 x 10 ⁶ BTU	0.58	0.70	1.3 x 10 ⁶ BTU	0.58	0.75
Supplies and analysis			<u>0.15</u>			<u>0.15</u>			<u>0.15</u>
Subtotal			64.18			66.17			69.94

Table 20
(continued)

<u>Semivariable Costs</u>	34-17-0 ^b			27-32-0 ^b			20-40-0 ^c		
	<u>Quantity/Ton</u>	<u>\$/Unit</u>	<u>\$/Ton</u>	<u>Quantity/Ton</u>	<u>\$/Unit</u>	<u>\$/Ton</u>	<u>Quantity/Ton</u>	<u>\$/Unit</u>	<u>\$/Ton</u>
Operating labor (0.184 man-hour at \$2.30 per hour)			0.42			0.42			0.42
Maintenance (5 percent of investment per year) ^f			0.83			0.83			0.83
Labor overhead (30 percent of operating labor and supervision)			<u>0.13</u>			<u>0.13</u>			<u>0.13</u>
Subtotal			1.38			1.38			1.38
<u>Fixed Costs</u>									
Plant overhead (70 percent of operating labor and supervision)			0.29			0.29			0.29
Depreciation (10 percent of investment per year) ^f			1.65			1.65			1.65
Taxes and insurance (2 percent of investment per year) ^f			0.33			0.33			0.33
Interest on working capital (7 percent) ^a			<u>1.12</u>			<u>1.12</u>			<u>1.12</u>
Subtotal			3.39			3.39			3.39
<u>Total Manufacturing Cost per Ton</u>			68.95			70.94			74.71

Table 20
(continued)

	34-17-0 ^b			27-32-0 ^b			20-40-0 ^c		
	<u>Quantity/Ton</u>	<u>\$/Unit</u>	<u>\$/Ton</u>	<u>Quantity/Ton</u>	<u>\$/Unit</u>	<u>\$/Ton</u>	<u>Quantity/Ton</u>	<u>\$/Unit</u>	<u>\$/Ton</u>
Return on investment (20 percent of investment per year) ^f			3.31			3.31			3.31
<u>Total Cost per Short Ton</u>			72.26			74.25			78.02
<u>Total Cost per Metric Ton</u>			79.49			81.68			85.82

- a. Assume that since recycle rate is about twice as great for urea-ammonium phosphate plant as for a diammonium phosphate plant, the investment cost for this plant would be about the same as a 1,000-ton-per-day diammonium phosphate plant which costs about \$1,700,000; and since this is a foreign plant, multiply investment by 1.33 = \$2,210,000; off-sites = \$380,000. Source Data: United Nations Fertilizer Manual. Working capital equals 60 days of variable plus semivariable cost plus 40 percent. Variable cost for three grades averaged in all countries considered.
- b. P₂O₅ of grade combined with ammonia to form diammonium phosphate.
- c. P₂O₅ of grade combined with ammonia to form mono-ammonium phosphate.
- d. 2.5 percent conditioner because grade contains considerable urea.
- e. 2 percent conditioner.
- f. Calculated using battery limits plant plus off-sites.

Table 21

ESTIMATED PRODUCTION COST OF UREA-AMMONIUM PHOSPHATE
FROM UREA-AMMONIA SOLUTION AND SUPERPHOSPHORIC ACID, TURKEY

Plant location: Istanbul, Turkey

Plant capacity: 550 tons per day, 340-day year, 187,000 tons per year.

Fixed investments: Battery limits plant, \$2,210,000; off-sites, \$880,000; working capital, \$3,000,000.^a

<u>Variable Costs</u>	<u>34-17-0^b</u>			<u>27-32-0^b</u>			<u>20-40-0^c</u>		
	<u>Quantity/Ton</u>	<u>\$/Unit</u>	<u>\$/Ton</u>	<u>Quantity/Ton</u>	<u>\$/Unit</u>	<u>\$/Ton</u>	<u>Quantity/Ton</u>	<u>\$/Unit</u>	<u>\$/Ton</u>
Superphosphoric acid (70-percent P ₂ O ₅)	0.248 T	87.49	21.70	0.467 T	87.49	40.86	0.583 T	87.49	51.01
Urea-ammonia solution (33-percent N)	0.440 T	29.62	13.03	0.835 T	29.62	24.73	0.618 T	29.62	18.31
Urea	0.449 T	62.66	28.13	-	-	-	-	-	-
Conditioner	0.025 T ^d	56.00	1.40	0.020 T ^e	56.00	1.12	0.020 T ^e	56.00	1.12
Water	0.60 M gals.	0.02	0.01	0.60 M gals.	0.02	0.01	0.60 M gals.	0.02	0.01
Power	20 kwh	0.010	0.20	20 kwh	0.010	0.20	20 kwh	0.010	0.20
Supplies and analysis			0.15			0.15			0.15
Fuel oil	1.1 x 10 ⁶ BTU	0.33	<u>0.36</u>	1.2x 10 ⁶ BTU	0.33	<u>0.40</u>	1.3 x 10 ⁶ BTU	0.33	<u>0.43</u>
Subtotal			64.98			67.47			71.23

Table 21
(continued)

<u>Semivariable Costs</u>	34-17-0 ^b			27-32-0 ^b			20-40-0 ^c		
	<u>Quantity/Ton</u>	<u>\$/Unit</u>	<u>\$/Ton</u>	<u>Quantity/Ton</u>	<u>\$/Unit</u>	<u>\$/Ton</u>	<u>Quantity/Ton</u>	<u>\$/Unit</u>	<u>\$/Ton</u>
Operating labor (0.184 man-hour at \$2.30 per hour)			0.42			0.42			0.42
Maintenance (5 percent of investment per year) ^f			0.83			0.83			0.83
Labor overhead (30 percent of operating labor and supervision)			<u>0.13</u>			<u>0.13</u>			<u>0.13</u>
Subtotal			1.38			1.38			1.38
<u>Fixed Costs</u>									
Plant overhead (70 percent of operating labor and supervision)			0.29			0.29			0.29
Depreciation (10 percent of investment per year) ^f			1.65			1.65			1.65
Taxes and insurance (2 percent of investment per year) ^f			0.33			0.33			0.33
Interest on working capital (7 percent) ^a			<u>1.12</u>			<u>1.12</u>			<u>1.12</u>
Subtotal			3.39			3.39			3.39
<u>Total Manufacturing Cost</u>			69.75			72.24			76.00

Table 21
(continued)

	34-17-0 ^b			27-32-0 ^b			20-40-0 ^c		
	Quantity/Ton	\$/Unit	\$/Ton	Quantity/Ton	\$/Unit	\$/Ton	Quantity/Ton	\$/Unit	\$/Ton
Return on investment (20 percent of investment per year) ^f			3.31			3.31			3.31
<u>Total Cost per Short Ton</u>			73.06			75.55			79.31
<u>Total Cost per Metric Ton</u>			80.37			83.11			87.24

- a. Assume that since recycle rate is about twice as great for urea-ammonium phosphate plant as for a diammonium phosphate plant, the investment cost for this plant would be about the same as a 1,000-ton-per-day diammonium phosphate plant which costs about \$1,700,000; and since this is a foreign plant, multiply investment by 1.33 = \$2,210,000; off-sites = \$880,000. Source Data: United Nations Fertilizer Manual. Working capital equals 60 days of variable plus semivariable cost plus 40 percent. Variable cost for three grades averaged in all countries considered.
- b. P₂O₅ of grade combined with ammonia to form diammonium phosphate.
- c. P₂O₅ of grade combined with ammonia to form mono-ammonium phosphate.
- d. 2.5 percent conditioner because grade contains considerable urea.
- e. 2 percent conditioner.
- f. Calculated using battery limits plant plus off-sites.

Table 22

ESTIMATED PRODUCTION COST OF UREA-AMMONIUM PHOSPHATE
FROM UREA-AMMONIA SOLUTION AND SUPERPHOSPHORIC ACID, INDIA

Plant location: Bombay, India

Plant capacity: 550 tons per day, 340-day year, 187,000 tons per year.

Fixed investments: Battery limits plant, \$2,210,000; off-sites, \$880,000; working capital, \$3,000,000.^a

Grade Variable Costs	34-17-0 ^b			27-32-0 ^b			20-40-0 ^c		
	Quantity/Ton	\$/Unit	\$/Ton	Quantity/Ton	\$/Unit	\$/Ton	Quantity/Ton	\$/Unit	\$/Ton
Superphosphoric acid (70-percent P ₂ O ₅)	0.248 T	94.17	23.35	0.467 T	94.17	43.98	0.583 T	94.17	54.90
Urea-ammonia solution (33-percent N)	0.440 T	33.63	14.80	0.835 T	33.63	28.08	0.618 T	33.63	20.78
Urea	0.449 T	66.66	29.93	-	-	-	-	-	-
Conditioner	0.025 T ^d	60.00	1.50	0.020 T ^e	60.00	1.20	0.020 T ^e	60.00	1.20
Water	0.60 M gals.	0.02	0.01	0.60 M gals.	0.02	0.01	0.60 M gals.	0.02	0.01
Power	20 kwh	0.01	0.20	20 kwh	0.01	0.20	20 kwh	0.01	0.20
Supplies and analysis			0.15			0.15			0.15
Fuel oil	1.1x10 ⁶ BTU	0.50	<u>0.55</u>	1.2x10 ⁶ BTU	0.50	<u>0.60</u>	1.3x10 ⁶ BTU	0.50	<u>0.65</u>
Subtotal			70.49			74.22			77.89

Table 22
(continued)

Grade	34-17-0 ^b			27-32-0 ^b			20-40-0 ^c		
	Quantity/Ton	\$/Unit	\$/Ton	Quantity/Ton	\$/Unit	\$/Ton	Quantity/Ton	\$/Unit	\$/Ton
<u>Semivariable Costs</u>									
Operating labor (0.184 man-hour at \$2.30 per hour)			0.42			0.42			0.42
Maintenance (5 percent of investment per year) ^f			0.83			0.83			0.83
Labor overhead (30 percent of operating labor and supervision)			<u>0.13</u>			<u>0.13</u>			<u>0.13</u>
Subtotal			1.38			1.38			1.38
<u>Fixed Cost</u>									
Plant overhead (70 percent of operating labor and supervision)			0.29			0.29			0.29
Depreciation (10 percent of investment per year) ^f			1.65			1.65			1.65
Taxes and insurance (2 percent of investment per year) ^f			0.33			0.33			0.33
Interest on working capital (7 percent) ^a			<u>1.12</u>			<u>1.12</u>			<u>1.12</u>
Subtotal			3.39			3.39			3.39
<u>Total Manufacturing Cost</u>			75.26			78.99			82.66
Return on investment (20 percent of investment per year) ^f			3.31			3.31			3.31

Table 22
(continued)

	34-17-0 ^b			27-32-0 ^b			20-40-0 ^c		
	Quantity/Ton	\$/Unit	\$/Ton	Quantity/Ton	\$/Unit	\$/Ton	Quantity/Ton	\$/Unit	\$/Ton
<u>Total Cost per Short Ton</u>			78.57			82.30			85.97
<u>Total Cost per Metric Ton</u>			86.43			90.53			94.57

- a. Assume that since recycle rate is about twice as great for urea-ammonium phosphate plant as for a diammonium phosphate plant, the investment cost for this plant would be about the same as a 1,000-ton-per-day diammonium phosphate plant which costs about \$1,700,000; and since this is a foreign plant, multiply investment by 1.33 = \$2,210,000; off-sites = \$880,000. Source Data: United Nations Fertilizer Manual. Working capital equals 60 days of variable plus semivariable cost plus 40 percent. Variable cost for three grades averaged in all countries considered.
- b. P₂O₅ of grade combined with ammonia to form diammonium phosphate.
- c. P₂O₅ of grade combined with ammonia to form mono-ammonium phosphate.
- d. 2.5 percent conditioner because grade contains considerable urea.
- e. 2 percent conditioner.
- f. Calculated using battery limits plant plus off-sites.

Table 23

ESTIMATED PRODUCTION COST OF UREA-AMMONIUM PHOSPHATE
FROM UREA-AMMONIA SOLUTION AND SUPERPHOSPHORIC ACID, NIGERIA

Plant location: Lagos, Nigeria

Plant capacity: 550 tons per day, 300-day year, 165,000 tons per year.

Fixed investments: Battery limits plant, \$2,210,000; off-sites, \$880,000; working capital, \$3,000,000.^a

Variable Costs	34-17-0 ^b			27-32-0 ^b			20-40-0 ^c		
	Quantity/Ton	\$/Unit	\$/Ton	Quantity/Ton	\$/Unit	\$/Ton	Quantity/Ton	\$/Unit	\$/Ton
Superphosphoric acid (70-percent P ₂ O ₅)	0.248 T	86.47	21.44	0.467 T	86.47	40.38	0.538 T	86.47	46.52
Urea-ammonia solution (33-percent N)	0.440 T	29.09	12.80	0.835 T	29.09	24.29	0.618 T	29.09	17.98
Urea	0.449 T	62.66	28.13	-	-	-	-	-	-
Water	0.60 M gals.	0.02	0.01	0.60 M gals.	0.02	0.01	0.60 M gals.	0.02	0.01
Conditioner	0.025 T ^d	56.00	1.40	0.020 T ^e	56.00	1.12	0.020 T ^e	56.00	1.12
Power	20 kwh	0.025	0.50	20 kwh	0.025	0.50	20 kwh	0.025	0.50
Supplies and analysis			0.15			0.15			0.15
Fuel	1.1x10 ⁶ BTU	0.28	<u>0.31</u>	1.2x10 ⁶ BTU	0.28	<u>0.33</u>	1.3 x10 ⁶ BTU	0.28	<u>0.36</u>
Subtotal			64.74			66.78			66.64

Table 23
(continued)

Semivariable Costs	34-17-0 ^b			27-32-0 ^b			20-40-0 ^c		
	Quantity/Ton	\$/Unit	\$/Ton	Quantity/Ton	\$/Unit	\$/Ton	Quantity/Ton	\$/Unit	\$/Ton
Operating labor (0.184 man-hour at \$2.30 per hour)			0.42			0.42			0.42
Maintenance (5 percent of investment per year) ^f			0.83			0.83			0.83
Labor overhead (30 percent of operating labor and supervision)			<u>0.13</u>			<u>0.13</u>			<u>0.13</u>
Subtotal			1.38			1.38			1.38
<u>Fixed Costs</u>									
Plant overhead (70 percent of operating labor and supervision)			0.29			0.29			0.29
Depreciation (10 percent of investment per year) ^f			1.65			1.65			1.65
Taxes and insurance (2 percent of investment per year) ^f			0.33			0.33			0.33
Interest on working capital (7 percent) ^a			<u>1.12</u>			<u>1.12</u>			<u>1.12</u>
Subtotal			3.39			3.39			3.39
<u>Total Manufacturing Cost</u>			69.51			71.55			71.41
Return on investment (20 percent of investment per year) ^f			3.31			3.31			3.31

Table 23
(continued)

	34-17-0 ^b			27-32-0 ^b			20-40-0 ^c		
	Quantity/Ton	\$/Unit	\$/Ton	Quantity/Ton	\$/Unit	\$/Ton	Quantity/Ton	\$/Unit	\$/Ton
<u>Total Cost per Short Ton</u>			72.82			74.86			74.72
<u>Total Cost per Metric Ton</u>			80.10			82.35			82.19

- a. Assume that since recycle rate is about twice as great for urea-ammonium phosphate plant as for a diammonium phosphate plant, the investment cost for this plant would be about the same as a 1,000-ton-per-day diammonium phosphate plant which costs about \$1,700,000; and since this is a foreign plant, multiply investment by 1.33= \$2,210,000; off-sites = \$880,000. Source Data: United Nations Fertilizer Manual. Working capital equals 60 days of variable plus semivariable cost plus 40 percent. Variable cost for three grades averaged in all countries considered.
- b. P₂O₅ of grade combined with ammonia to form diammonium phosphate.
- c. P₂O₅ of grade combined with ammonia to form mono-ammonia phosphate.
- d. 2.5 percent conditioner because grade contains considerable urea.
- e. 2 percent conditioner.
- f. Calculated using battery limits plant plus off-sites.

Table 24

ESTIMATED PRODUCTION COST OF UREA-AMMONIUM PHOSPHATE
FROM AMMONIA, SOLID UREA AND SUPERPHOSPHORIC ACID, BRAZIL

Plant location: Santos, Brazil

Plant capacity: 550 tons per day, 340-day year, 187,000 tons per year.

Fixed investments: Battery limits plant, \$1,862,000; off-sites, \$744,000; working capital, \$3,000,000.^a

Variable Costs	34-17-0 ^b			27-32-0 ^b			20-40-0 ^c		
	Quantity/Ton	\$/Unit	\$/Ton	Quantity/Ton	\$/Unit	\$/Ton	Quantity/Ton	\$/Unit	\$/Ton
Superphosphoric acid (70-percent P ₂ O ₅)	0.248 T	85.73	21.26	0.467 T	85.73	40.04	0.583 T	85.73	49.98
Urea (45-percent N)	0.619 T	62.16	38.48	0.326 T	62.16	20.26	0.222 T	62.16	13.80
Ammonia	0.084 T	52.65	4.42	0.157 T	52.65	8.27	0.127 T	52.65	6.69
Conditioner	0.025 T ^d	55.50	1.39	0.010 T ^e	55.50	0.56	0.02 T ^f	55.50	1.11
Water	0.60 M gals.	0.02	0.01	0.60	0.02	0.01	0.60	0.02	0.01
Power	20 kwh	0.010	0.20	20 kwh	0.010	0.20	20 kwh	0.010	0.20
Supplies and analysis			0.15			0.15			0.15
Fuel oil	1.1x10 ⁶ BTU	58.0	<u>0.64</u>	1.1x10 ⁶ BTU	58.0	<u>0.64</u>	1.1x10 ⁶ BTU	58.0	<u>0.64</u>
Subtotal			66.55			70.13			72.58

Table 24
(continued)

Semivariable Costs	34-17-0 ^b			27-32-0 ^b			20-40-0 ^c		
	Quantity/Ton	\$/Unit	\$/Ton	Quantity/Ton	\$/Unit	\$/Ton	Quantity/Ton	\$/Unit	\$/Ton
Operating labor (0.184 man-hour at \$2.30 per hour)			0.42			0.42			0.42
Maintenance (5 percent of investment per year) ^g			0.70			0.70			0.70
Labor overhead (30 percent of operating labor and supervision)			<u>0.13</u>			<u>0.13</u>			<u>0.13</u>
Subtotal			1.25			1.25			1.25
Fixed Costs									
Plant overhead (70 percent of operating labor and supervision)			0.29			0.29			0.29
Depreciation (10 percent of investment per year) ^g			1.39			1.39			1.39
Taxes and insurance (2 percent of investment per year) ^g			0.28			0.28			0.28
Interest on working capital (7 percent) ^a			<u>1.12</u>			<u>1.12</u>			<u>1.12</u>
Subtotal			3.08			3.08			3.08
Total Manufacturing Cost			70.88			74.46			76.91
Return on investment (20 percent of investment per year) ^g			2.79			2.79			2.79

Table 24
(continued)

	34-17-0 ^b			27-32-0 ^b			20-40-0 ^c		
	Quantity/Ton	\$/Unit	\$/Ton	Quantity/Ton	\$/Unit	\$/Ton	Quantity/Ton	\$/Unit	\$/Ton
<u>Total Cost per Short Ton</u>			73.67			77.25			79.70
<u>Total Cost per Metric Ton</u>			81.04			84.98			87.67

- a. Assume that since recycle rate is about 1.2 as high for urea-ammonium phosphate plant as a diammonium phosphate plant, the investment cost for this battery limits plant would be about the same as a 700-ton-per-day diammonium phosphate plant which would cost \$1,400,000 according to United Nations Fertilizer Manual; and since this is a foreign investment, total plant investment, $\$1,400,000 \times 1.33 = \$1,862,000$; off-sites, \$744,000; working capital, 60 days of average semivariable plus variable cost for all countries plus 40 percent.
- b. P₂O₅ of grade combines as diammonium phosphate.
- c. About 80 percent of P₂O₅ in grade combined as mono-ammonium phosphate.
- d. 2.5 percent conditioner because grade contains considerable urea.
- e. 1 percent conditioner necessary to make grade product. Should store well.
- f. 2 percent conditioner.
- g. Calculated using sum of battery limits plant plus off-sites.

Table 25

ESTIMATED PRODUCTION COST UREA-AMMONIUM PHOSPHATE
FROM AMMONIA, SOLID UREA AND SUPERPHOSPHORIC ACID, TURKEY

Plant location: Istanbul, Turkey

Plant capacity: 550 tons per day, 340-day year, 187,000 tons per year.

Fixed investments: Battery limits plant, \$1,852,000; off-sites, \$744,000; working capital, \$3,000,000.^a

<u>Variable Costs</u>	<u>34-17-0^b</u>			<u>27-32-0^b</u>			<u>20-40-0^c</u>		
	<u>Quantity/Ton</u>	<u>\$/Unit</u>	<u>\$/Ton</u>	<u>Quantity/Ton</u>	<u>\$/Unit</u>	<u>\$/Ton</u>	<u>Quantity/Ton</u>	<u>\$/Unit</u>	<u>\$/Ton</u>
Superphosphoric acid (70-percent P ₂ O ₅)	0.248 T	87.49	21.70	0.467 T	87.49	40.86	0.583 T	87.49	51.01
Urea (45-percent N)	0.619 T	62.66	38.79	0.326 T	62.66	20.43	0.222 T	62.66	13.91
Ammonia	0.084 T	50.65	4.25	0.157 T	50.65	7.95	0.127 T	50.65	6.43
Conditioner	0.025 T ^d	56.00	1.40	0.010 T ^e	56.00	0.56	0.02 T ^f	56.00	1.12
Water	0.60 M gals.	0.02	0.01	0.60 M gals.	0.02	0.01	0.60 M gals.	0.02	0.01
Power	20 kwh	0.01	0.20	20 kwh	0.01	0.20	20 kwh	0.01	0.20
Supplies and analysis			0.15			0.15			0.15
Fuel oil	1.1x10 ⁶ BTU	0.33	<u>0.36</u>	1.1x10 ⁶ BTU	0.33	<u>0.36</u>	1.1x10 ⁶ BTU	0.33	<u>0.36</u>
Subtotal			66.86			70.52			73.19

Table 25
(continued)

<u>Semivariable Costs</u>	34-17-0 ^b			27-32-0 ^b			20-40-0 ^c		
	<u>Quantity/Ton</u>	<u>\$/Unit</u>	<u>\$/Ton</u>	<u>Quantity/Ton</u>	<u>\$/Unit</u>	<u>\$/Ton</u>	<u>Quantity/Ton</u>	<u>\$/Unit</u>	<u>\$/Ton</u>
Operating labor (0.184 man-hour at \$2.30 per hour)			0.42			0.42			0.42
Maintenance (5 percent of investment per year) ^g			0.70			0.70			0.70
Labor overhead (30 percent of operating labor and supervision)			<u>0.13</u>			<u>0.13</u>			<u>0.13</u>
Subtotal			1.25			1.25			1.25
<u>Fixed Costs</u>									
Plant overhead (70 percent of operating labor and supervision)			0.29			0.29			0.29
Depreciation (10 percent of investment per year) ^g			1.39			1.39			1.39
Taxes and insurance (2 percent of investment per year) ^g			0.28			0.28			0.28
Interest on working capital (7 percent) ^a			<u>1.12</u>			<u>1.12</u>			<u>1.12</u>
Subtotal			3.08			3.08			3.08
<u>Total Manufacturing Cost</u>			71.19			74.85			77.52
Return on investment (20 percent of investment per year) ^g			2.79			2.79			2.79

Table 25
(continued)

	34-17-0 ^b			27-32-0 ^b			20-40-0 ^c		
	Quantity/Ton	\$/Unit	\$/Ton	Quantity/Ton	\$/Unit	\$/Ton	Quantity/Ton	\$/Unit	\$/Ton
<u>Total Cost per Short Ton</u>			73.98			77.64			80.31
<u>Total Cost per Metric Ton</u>			81.38			85.40			88.34

- a. Assume that since recycle rate is about 1.2 as high for urea-ammonium phosphate plant as a diammonium phosphate plant, the investment cost for this battery limits plant would be about the same as a 700-ton-per-day diammonium phosphate plant which would cost \$1,400,000 according to United Nations Fertilizer Manual; and since this is a foreign investment, total plant investment, $\$1,400,000 \times 1.33 = \$1,862,000$; off-sites, \$744,000; working capital, 60 days of average semivariable plus variable cost for all countries plus 40 percent.
- b. P₂O₅ of grade combined as diammonium phosphate.
- c. About 80 percent of P₂O₅ in grade combined as mono-ammonium phosphate.
- d. 2.5 percent conditioner because grade contains considerable urea.
- e. 1 percent conditioner necessary to make grade product. Should store well.
- f. 2 percent conditioner.
- g. Calculated using sum of battery limits plant plus off-sites.

Table 26

ESTIMATED PRODUCTION COST OF UREA-AMMONIUM PHOSPHATE
FROM AMMONIA, SOLID UREA AND SUPERPHOSPHORIC ACID, INDIA

Plant location: Bombay, India

Plant capacity: 550 tons per day, 340-day year, 187,000 tons per year.

Fixed investments: Battery limits plant, \$1,862,000; off-sites, \$744,000; working capital, \$3,000,000.^a

Variable Costs	34-17-0 ^b			27-32-0 ^b			20-40-0 ^c		
	Quantity/Ton	\$/Unit	\$/Ton	Quantity/Ton	\$/Unit	\$/Ton	Quantity/Ton	\$/Unit	\$/Ton
Superphosphoric acid (70-percent P ₂ O ₅)	0.248 T	94.17	23.35	0.467 T	94.17	43.98	0.583 T	94.17	54.90
Urea (45-percent N)	0.619 T	66.66	41.26	0.326 T	66.66	21.73	0.222 T	66.66	14.80
Ammonia	0.084 T	58.15	4.88	0.157 T	58.15	9.13	0.127 T	58.15	7.39
Water	0.60 M gals.	0.02	0.01	0.60 M gals.	0.02	0.01	0.60 M gals.	0.02	0.01
Conditioner	0.025 T ^d	60.00	1.50	0.010 T ^e	60.00	0.60	0.02 T ^f	60.00	1.20
Supplies and analysis			0.15			0.15			0.15
Power	20 kwh	0.01	0.20	20 kwh	0.01	0.20	20 kwh	0.01	0.20
Fuel oil	1.1x10 ⁶ BTU	0.50	<u>0.55</u>	1.1x10 ⁶ BTU	0.50	<u>0.55</u>	1.1x10 ⁶ BTU	0.50	<u>0.55</u>
Subtotal			71.90			76.35			79.20

Table 26
(continued)

<u>Semivariable Costs</u>	<u>34-17-0^b</u>			<u>27-32-0^b</u>			<u>20-40-0^c</u>		
	<u>Quantity/Ton</u>	<u>\$/Unit</u>	<u>\$/Ton</u>	<u>Quantity/Ton</u>	<u>\$/Unit</u>	<u>\$/Ton</u>	<u>Quantity/Ton</u>	<u>\$/Unit</u>	<u>\$/Ton</u>
Operating labor (0.184 man-hour at \$2.30 per hour)			0.42			0.42			0.42
Maintenance (5 percent of investment per year) ^g			0.70			0.70			0.70
Labor overhead (30 percent of operating labor and supervision)			<u>0.13</u>			<u>0.13</u>			<u>0.13</u>
Subtotal			1.25			1.25			1.25
<u>Fixed Costs</u>									
Plant overhead (70 percent of operating labor and supervision)			0.29			0.29			0.29
Depreciation (10 percent of investment per year) ^g			1.39			1.39			1.39
Taxes and insurance (2 percent of investment per year) ^g			0.28			0.28			0.28
Interest on working capital (7 percent) ^a			<u>1.12</u>			<u>1.12</u>			<u>1.12</u>
Subtotal			3.08			3.08			3.08
<u>Total Manufacturing Cost</u>			76.23			80.68			83.53
Return on investment (20 percent of investment per year) ^g			2.79			2.79			2.79

Table 26
(continued)

	34-17-0 ^b		27-32-0 ^b			20-40-0 ^c			
	Quantity/Ton	\$/Unit	\$/Ton	Quantity/Ton	\$/Unit	\$/Ton	Quantity/Ton	\$/Unit	\$/Ton
<u>Total Cost per Short Ton</u>			79.02			83.47			86.32
<u>Total Cost per Metric Ton</u>			86.92			91.82			94.95

- a. Assume that since recycle rate is about 1.2 as high for urea-ammonium phosphate plant as a diammonium phosphate plant, the investment cost for this battery limits plant would be about the same as a 700-ton-per-day diammonium phosphate plant which would cost \$1,400,000 according to United Nations Fertilizer Manual; and since this is a foreign investment, total plant investment, $\$1,400,000 \times 1.33 = \$1,862,000$; off-sites, \$744,000; working capital, 60 days of average semivariable plus variable cost for all countries plus 40 percent.
- b. P₂O₅ of grade combined as diammonium phosphate.
- c. About 80 percent of P₂O₅ in grade combined as mono-ammonium phosphate.
- d. 2.5 percent conditioner because grade contains considerable urea.
- e. 1 percent conditioner necessary to make grade product. Should store well.
- f. 2 percent conditioner.
- g. Calculated using sum of battery limits plant plus off-sites.

Table 27

ESTIMATED PRODUCTION COST OF UREA-AMMONIUM PHOSPHATE
FROM AMMONIA, SOLID UREA AND SUPERPHOSPHORIC ACID, NIGERIA

Plant location: Lagos, Nigeria

Plant capacity: 550 tons per day, 340-day year, 187,000 tons per year.

Fixed investments: Battery limits plant, \$1,862,000; off-sites, \$744,000; working capital, \$3,000,000.^a

Variable Costs	34-17-0 ^b			27-32-0 ^b			20-40-0 ^c		
	Quantity/Ton	\$/Unit	\$/Ton	Quantity/Ton	\$/Unit	\$/Ton	Quantity/Ton	\$/Unit	\$/Ton
Superphosphoric acid (70-percent P ₂ O ₅)	0.248 T	86.47	21.44	0.467 T	86.47	40.38	0.583 T	86.47	50.41
Urea (45-percent N)	0.619 T	62.66	38.79	0.326 T	62.66	20.43	0.222 T	62.66	13.91
Ammonia	0.084 T	51.15	4.30	0.157 T	51.15	8.03	0.127 T	51.15	6.50
Water	0.60 M gals.	0.02	0.01	0.60 M gals.	0.02	0.01	0.60 M gals.	0.02	0.01
Conditioner	0.025 T ^d	56.00	1.40	0.010 T ^e	56.00	0.56	0.02 T ^f	56.00	1.12
Supplies and analysis			0.15			0.15			0.15
Power	20 kwh	0.025	0.50	20 kwh	0.025	0.50	20 kwh	0.025	0.50
Fuel (natural gas)	1.1x10 ⁶ BTU	0.28	<u>0.31</u>	1.1x10 ⁶ BTU	0.28	<u>0.31</u>	1.1x10 ⁶ BTU	0.28	<u>0.31</u>
Subtotal			66.90			70.37			72.91

Table 27
(continued)

<u>Semivariable Costs</u>	<u>34-17-0^b</u>			<u>27-32-0^b</u>			<u>20-40-0^c</u>		
	<u>Quantity/Ton</u>	<u>\$/Unit</u>	<u>\$/Ton</u>	<u>Quantity/Ton</u>	<u>\$/Unit</u>	<u>\$/Ton</u>	<u>Quantity/Ton</u>	<u>\$/Unit</u>	<u>\$/Ton</u>
Operating labor (0.184 man-hour at \$2.30 per hour)			0.42			0.42			0.42
Maintenance (5 percent of investment per year) ^g			0.70			0.70			0.70
Labor overhead (30 percent of operating labor and supervision)			<u>0.13</u>			<u>0.13</u>			<u>0.13</u>
Subtotal			1.25			1.25			1.25
<u>Fixed Costs</u>									
Plant overhead (70 percent of operating labor and supervision)			0.29			0.29			0.29
Depreciation (10 percent of investment per year) ^g			1.39			1.39			1.39
Taxes and insurance (2 percent of investment per year) ^g			0.28			0.28			0.28
Interest on working capital (7 percent) ^a			<u>1.12</u>			<u>1.12</u>			<u>1.12</u>
Subtotal			3.08			3.08			3.08
<u>Total Manufacturing Cost</u>			71.23			74.70			77.24
Return on investment (20 percent of investment per year) ^g			2.79			2.79			2.79

Table 27
(continued)

	34-17-0 ^b			27-32-0 ^b			20-40-0 ^c		
	Quantity/Ton	\$/Unit	\$/Ton	Quantity/Ton	\$/Unit	\$/Ton	Quantity/Ton	\$/Unit	\$/Ton
<u>Total Cost per Short Ton</u>			74.02			77.49			80.03
<u>Total Cost per Metric Ton</u>			81.42			85.24			88.03

- a. Assume that since recycle rate is about 1.2 as high for urea-ammonium phosphate plant as a diammonium phosphate plant, the investment cost for this battery limits plant would be about the same as a 700-ton-per-day diammonium phosphate plant which would cost \$1,400,000 according to United Nations Fertilizer Manual; and since this is a foreign investment, total plant investment, $\$1,400,000 \times 1.33 = \$1,862,000$; off-sites, \$744,000; working capital, 60 days of average semivariable plus variable cost for all countries plus 40 percent.
- b. P₂O₅ of grade combined as diammonium phosphate.
- c. About 80 percent of P₂O₅ in grade combined as mono-ammonium phosphate.
- d. 2.5 percent conditioner because grade contains considerable urea.
- e. 1 percent conditioner necessary to make grade product. Should store well.
- f. 2 percent conditioner.
- g. Calculated using sum of battery limits plant plus off-sites.

Table 28

SUMMARY DATA COMPARING COSTS IN DESTINATION PORTS OF SOLID BULK UREA IMPORTED VERSUS ITS MANUFACTURE FROM UREA-AMMONIA SOLUTION IMPORTED;
AND COMPARING THE COSTS OF UREA-AMMONIUM PHOSPHATES PRODUCED WITH SUPERPHOSPHORIC ACID AND UREA-AMMONIA SOLUTION
VERSUS THEIR PRODUCTION FROM SUPERPHOSPHORIC ACID, AMMONIA AND SOLID UREA

<u>Locations Manufactured</u>	<u>Estimated Production Cost Dollars Per Ton (Short Ton)</u>				<u>Estimated Distance From New Orleans, La. Nautical Miles</u>
	<u>Urea</u>	<u>34-17-0</u>	<u>27-32-0</u>	<u>20-40-0</u>	
	<u>Urea from Urea-Ammonia Solution</u>	<u>Urea-Ammonium Phosphate from Urea-Ammonia Solution and Superphosphoric Acid</u>			
Brazil	63.08	72.26	74.25	78.02	5,183
Turkey	66.65	73.06	75.55	79.31	6,417
India	73.70	78.57	82.50	85.97	9,495
Nigeria	65.23	72.82	74.86	74.72	5,074
		<u>Urea-Ammonium Phosphate from Solid Urea, Ammonia and Superphosphoric Acid</u>			
	<u>Imported Urea</u>				
Brazil	62.16 ^a	73.63	77.25	79.70	5,183
Turkey	62.66	73.93	77.64	80.31	6,417
India	66.66	79.02	83.47	86.32	9,495
Nigeria	62.66	74.02	77.49	80.83	5,074
<u>Least-Cost Material</u>					
Brazil	Solid Urea	Urea-Ammonia Solution	Urea-Ammonia Solution	Urea-Ammonia Solution	5,183
Turkey	Solid Urea	Urea-Ammonia Solution	Urea-Ammonia Solution	Urea-Ammonia Solution	6,417
India	Solid Urea	Urea-Ammonia Solution	Urea-Ammonia Solution	Urea-Ammonia Solution	9,495
Nigeria	Solid Urea	Urea-Ammonia Solution	Urea-Ammonia Solution	Urea-Ammonia Solution	5,074
<u>Cost Difference, \$/Ton</u>					
<u>Importing Urea Vs. Urea-Ammonia Solution</u>					
Brazil	-0.92	+1.37	+3.00	+1.68	5,183
Turkey	-3.99	+0.92	+2.09	+1.00	6,417
India	-7.04	+0.45	+1.67	+0.35	9,495
Nigeria	-2.57	+1.20	+2.63	+5.31	5,074

a. The cost for solid urea in these cases pertains to production in the Gulf Coast area of the United States and shipment to designated destination countries.

Table 29

ALL RISK INSURANCE COSTS WITH REGARD TO SHIPPING FERTILIZER MATERIALSFROM GULF PORTS OF THE UNITED STATES TO VARIOUS DESTINATION PORTS

Delivery Ports	Materials	Insured Value/T ^a	Full Coverage			5-Percent Deductible		
			Rate/\$1.00 Ins. Value ^b	Ins. Cost/T	Insurance Cost/Unit Plant Food	Rate/\$1.00 Ins. Value ^b	Ins. Cost/T	Insurance Cost/Unit Plant Food
Santos, Brazil	Ammonia (82%)	\$ 49.91	\$0.0725	\$3.618	\$0.044	\$0.0400	\$1.996	\$0.024
	Solid urea (45%)	58.61	0.0100	0.586	0.130	-	-	-
	Urea-ammonia solution (33%)	26.65	0.0200	0.533	0.160	0.0060	0.160	0.048
	Superphosphoric acid (70%)	104.37	0.0200	2.087	0.030	0.0075	0.783	0.112
	Conditioner	55.50	0.0100	0.555	-	0.0100	0.555	-
Istanbul, Turkey	Ammonia (82%)	47.71	0.0500	2.386	0.029	0.0060	0.286	0.035
	Solid urea (45%)	59.16	0.0050	0.296	0.066	-	-	-
	Urea-ammonia solution (33%)	27.67	0.0150	0.415	0.126	0.0050	0.138	0.042
	Superphosphoric acid (70%)	106.30	0.0160	1.701	0.024	0.0070	0.744	0.106
	Conditioner	56.00	0.0050	0.280	-	0.0050	0.280	-
Bombay, India	Ammonia (82%)	55.96	0.0650	3.637	0.044	0.0100	0.560	0.068
	Solid urea (45%)	64.56	0.0085	0.540	0.120	-	-	-
	Urea-ammonia solution (33%)	32.08	0.0120	0.385	0.117	0.0045	0.144	0.044
	Superphosphoric acid (70%)	113.65	0.0140	1.591	0.023	0.0065	0.739	0.106
	Conditioner	60.00	0.0085	0.510	-	0.0085	0.510	-
Lagos, Nigeria	Ammonia (82%)	48.26	0.0500	2.413	0.029	0.0030	0.145	0.018
	Solid Urea (45%)	59.16	0.0075	0.444	0.135	-	-	-
	Urea-ammonia solution (33%)	27.08	0.0150	0.406	0.123	0.0060	0.162	0.049
	Superphosphoric acid (70%)	105.18	0.0160	1.683	0.024	0.0070	0.736	0.105
	Conditioner	56.00	0.0075	0.420	-	0.0075	0.420	-

a. Insured value is based on 110 percent of estimated U. S. production, storage, and loading cost plus ocean freight to destination ports plus unloading costs.

b. Based on estimates provided by a fertilizer exporting company.