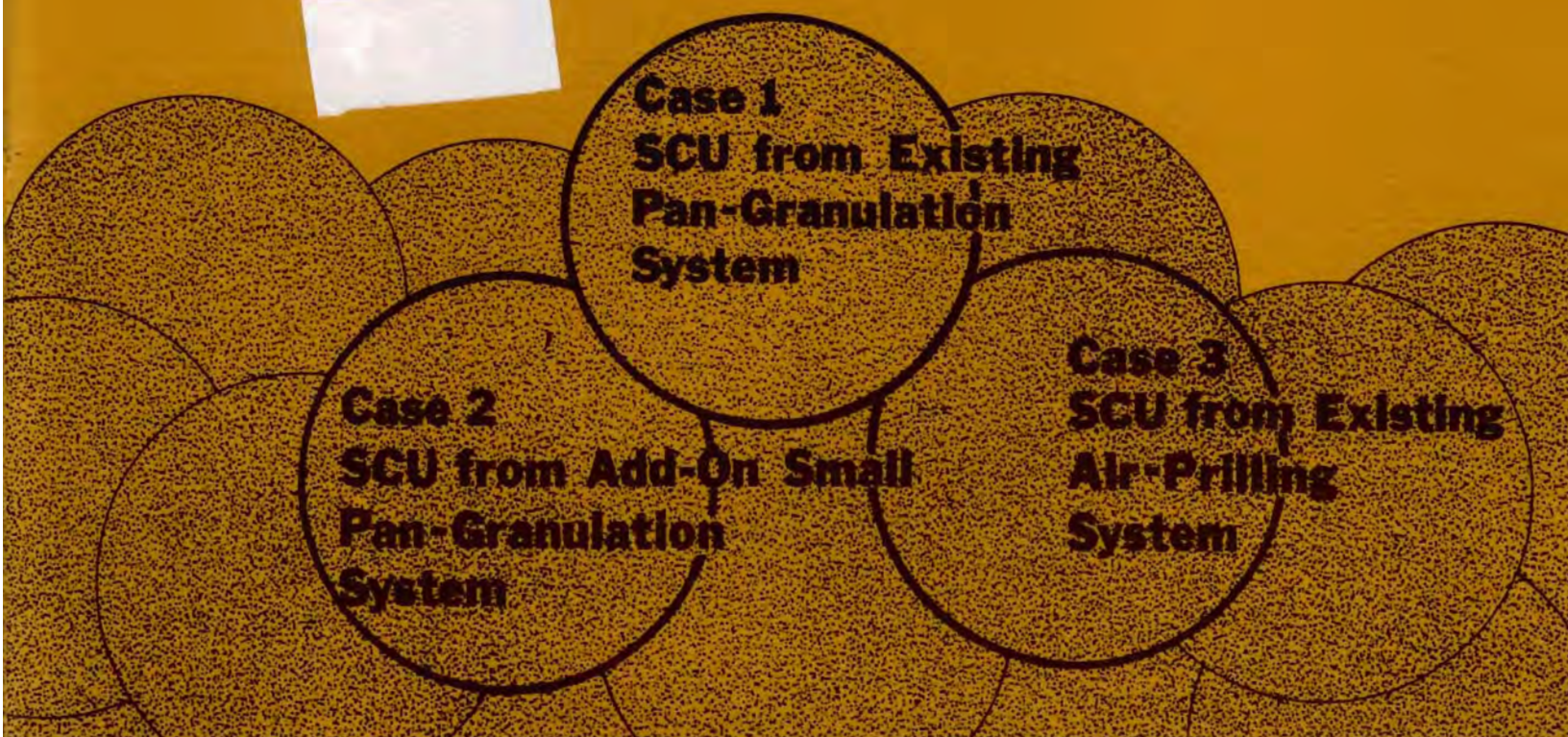
Sulfur-Coated Urea

Estimated Cost in a Developing Country



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SUMMARY

Sulfur-coated urea (SCU) is an effective controlled-release nitrogen fertilizer that TVA has developed for commercial production. Its improved agronomic performance and economic attractiveness have been demonstrated on selected crops, particularly intermittently flooded rice and sugarcane.

SCU is:

- A controlled-release nitrogen fertilizer that decreases losses of nitrogen through volatilization and/or leaching.
- An exceptionally good product for crops such as rice grown under poor water-management conditions and long-term crops such as sugarcane and pineapple, but not corn, wheat, or other crops that require relatively large amounts of N in a short period.
- A product having good physical properties for handling and storage even under high humidity conditions.
- A product that can be produced by a relatively simple process.
- A somewhat more expensive form of nitrogen, but much less costly than other forms of controlled-release nitrogen.
- A source of sulfur.
- A urea product compatible with granular superphosphates.

SCU is not yet being produced on a commercial scale, but is being produced by private industry in pilot plants in the U.S.A., Canada, Japan, and England. TVA has begun procurement of equipment for a 200-metric-ton-per-day plant to become operational in 1976.

It is estimated that in developing countries the in-plant price of SCU would be 25% to 40% more than that projected (1977) for uncoated urea, and about one-half the price of other commercial controlled-release nitrogen products (ureaform, IBDU, etc.). High benefit:cost ratios have been demonstrated for SCU on intermittently flooded rice and on sugarcane and pineapples.

Sulfur-Coated Urea

Estimated Production Cost & In-Plant Price in a Developing Country (Capacity, 200 Metric Tons Per Day)

Sulfur-coated urea (SCU) is a controlled-release nitrogen fertilizer that has been under extensive development and testing for 13 years at TVA (2, 3, 4, 6). Currently, a 1 ton/hour pilot plant (8) is producing material for agronomic testing throughout the world. The Agency for International Development (AID) is supporting agronomic research with this and other materials. Exceptionally good results have been obtained with a number of crops (1, 5), particularly rice that is flooded intermittently (7). SCU also has excellent physical properties, even in very humid climates.

This report gives an estimate of the production cost and in-plant price for SCU at a capacity of 200 mt/day for a developing-country situation. Three alternate cases were chosen for the basis of the estimate.

SCU PRODUCTION PROCESS

In the coating process shown in figure 1, the granular or prilled urea is preheated to about 150° to 160°F and then sprayed with atomized molten sulfur to form a uniform sulfur base coat on each particle; this is done with pressure-atomizing spray nozzles in a rotary drum. Depending upon the urea particle size, the sulfur content is about 16% (-6 +10 mesh granules) to 26% (-8 +14 mesh prills) of the product. Following the sulfur application, a thin film of microcrystalline wax, or other sealant such as a mixture of petroleum oil and low molecular weight polyethylene, is applied by spraying the molten sealant onto the sulfur-coated substrate in a second rotary drum; the product contains about 2% sealant. The product is then cooled in a rotary or fluid-bed cooler. In the last unit, a rotary drum, about 2% powdered conditioner is added to offset the tacky nature of the sealant.

Promising results have been obtained also with sulfur-only coating. In this version of the process, waxing and conditioning equipment is eliminated. Although the physical characteristics of this material cause it to break excessively in conventional fan-type, broadcast application equipment, its distribution by hand, as is the practice in most developing countries, should give no problems. This type product can be produced at a significantly lower cost than the sealed SCU. However, it has not been fully developed and tested at this time, so a detailed estimate is not included in this report.

SCOPE OF ESTIMATE

The estimation of production costs and in-plant prices of SCU depends heavily on the total capital investment for such a plant. The governing criterion for estimating capital investments in this report is the assumption that the plant is to be added to an existing ammonia-urea complex that has a larger urea capacity than that required for the 200 mt/day (66,000 mt/year) SCU unit under consideration. Three cases were considered:

Case A—An existing pan-granulation unit will provide onsize (-6 +10 mesh) feed to the SCU unit; the pan is assumed to handle the full urea plant output.

Case B—A small pan-granulation unit must be added to the larger complex to provide feed (-6 +10 mesh) for the SCU unit; only part of the urea plant output is processed.

Case C—The existing urea prilling unit will provide feed (-8 +14 mesh) for the SCU unit.

Flow diagrams of the three case processes are also shown in figure 1. The type of feed should have only a small effect on the sizing, and therefore on the cost, of the basic sulfur-coating plant itself. The total capital investment of the Case B SCU "complex" will, of course, be affected by the postulated addition of the small pan-granulation system.

ESTIMATED PLANT INVESTMENT

The total plant investment is arrived at by factoring the estimated delivered cost of the major items of SCU plant equipment given in the following equipment list.

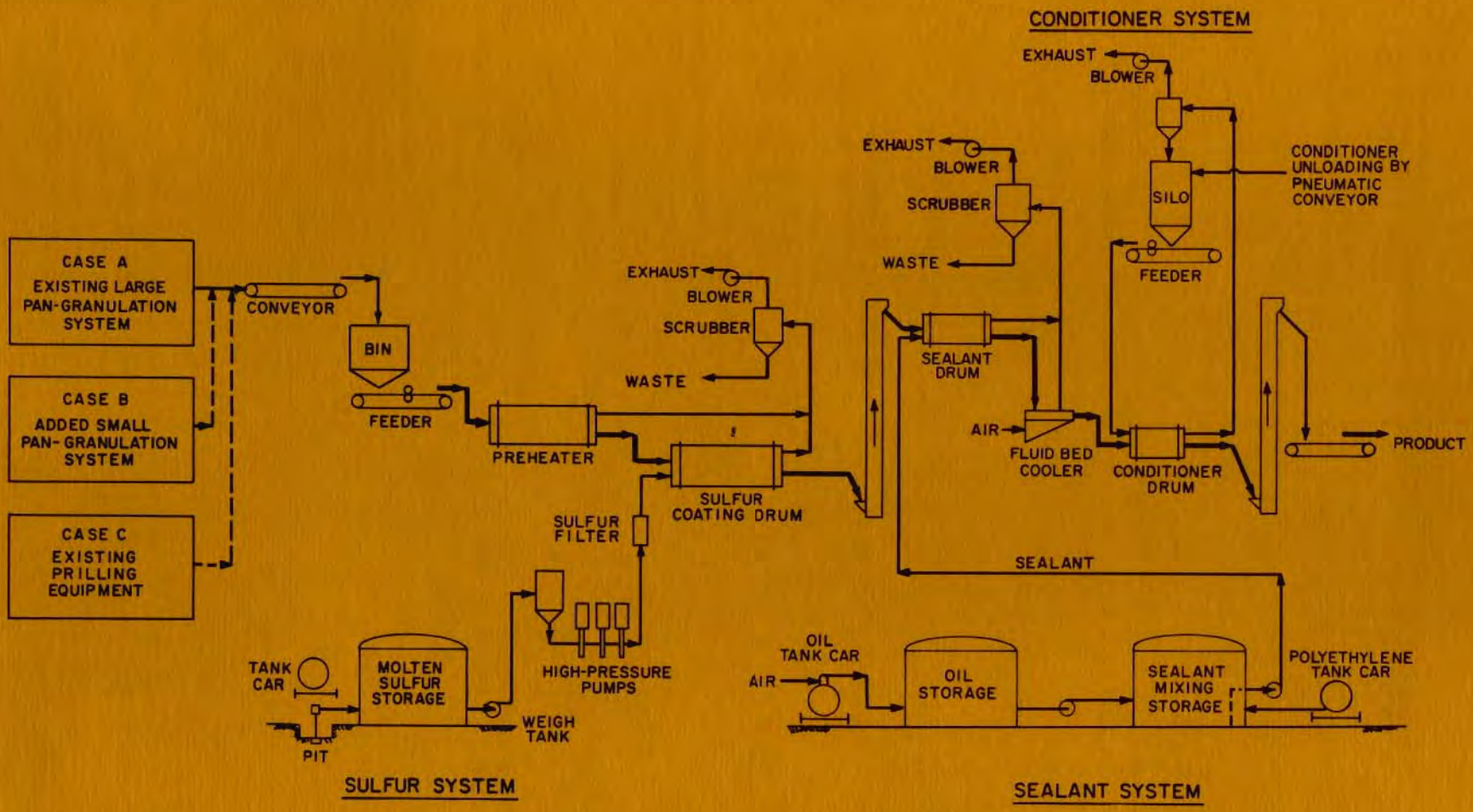

Figure 1. Flow diagram for 200-tqn-per-day sulfur-coated urea plant

	1974 U.S. cost, $
Urea feed system	
Feed bin conveyor	3,000
Feed bin (35-mt)	14,000
Feeder (15 mt/hr)	5,000
Preheater (5-ft diameter x 20-ft long)	20,000
Sulfur-coating drum (6-ft diameter x 20-ft long)	30,000
Coating drum elevator	16,000
Molten sulfur system	
Car unloading pit (15,000-gal)	20,000
Sulfur storage tank (80,000-gal)	60,000
Sulfur pumps (two transfer, three high-pressure duplex)	10,000
Sulfur weigh tank (200-gal)	2,000
Sulfur filter	5,000
Sealant system	
Oil storage (30,000-gal)	30,000
Mix-tank (45,000-gal)	35,000
Car unloading and transfer pumps (three)	3,000
Sealant pumps (two duplex)	4,000
Sealant coating drum (6-ft diameter x 6-ft long)	10,000
Fluid bed cooler	25,000
Conditioning system	
Conditioner silo (5-ft diameter x 10-ft high)	7,000
Feeder, 0.5 mt/hr	2,000
Bag filter and blower[a]	10,000
Conditioning drum (4-ft diameter x 8-ft long)	10,000
Conditioning drum elevator	10,000
Product handling system (two conveyors to storage)[a]	12,000
Vent systems (preheater plus sulfur coating drum; fluid bed cooler and wax drum)[a]	25,000
Total plant equipment cost (P.E.C.), delivered	**368,000**

[a]Minimal for developing countries.

Using the Miller[1] AMPI factored plant investment estimating procedure, the following values are obtained.

Item	Factor	Cost, $ U.S.
Battery limits (B.L.) plant investment	2.31 x P.E.C.	850,000
Storage and handling modifications	0.04 x B.L.	34,000
Utilities tie-in and modification	0.10 x B.L.	85,000
Subtotal		969,000
Services–0.04 x subtotal		39,000
Total direct costs		**1,008,000**
Indirect costs		
Field construction overhead plus profit (25% direct cost)		250,000
Engineering (10% direct cost)		100,000
Subtotal		1,358,000
Contingency (15% subtotal)		203,700
Total plant investment (U.S.)		**1,560,000**

It is generally assumed that construction costs in developing countries will be about 25% greater than those in the United States. As a result, the estimated plant investment for the basic 200 mt/day SCU unit in a developing country is:

$$1.25 \times \$1{,}560{,}000 = \$1{,}950{,}000$$

This amount assumes " instant" planning and erection in 1974. If a 3-year lead time is postulated for planning and construction, an escalation factor of 10%/year, or 1.33, would be required. Thus, the plant investment would increase to:

$$1.33 \times \$1{,}950{,}000 = \$2{,}600{,}000$$

This value would apply in the estimated production costs for SCU in Cases A and C.

In Case B, the estimated cost of the additional 160 mt/day pan granulation required to feed the coating unit would be added to the above plant investment. In a previous estimate (1972), the plant investment for a 360-mt/day urea pan-granulation unit was calculated to be $1,000,000, not including urea solution evaporators. Since the urea solution evaporators are likewise assumed to be an integral part of the urea plant in this estimate and are, therefore, common to all cases, the additional plant investment (1974) for Case B is calculated to be:

[1]*Modern Cost-Engineering Techniques*, H. Poppers, ed., McGraw-Hill Book Company, New York, 59-67. 1970.

$$\frac{(160)^{0.7}}{(360)} \times \frac{1.54}{1.34} \times \$1.0 \text{ MM} = \$660{,}000 \text{ U.S.}^2$$

or = $820,000 LDC (1.25 x 4.5)

and, total plant investment, Case B = $2,770,000 ($1,950,000 + $820,000). Escalation to 1977 would result in a total investment for Case B of:

$$1.33 \times \$2{,}770{,}000 = \$3{,}680{,}000$$

A summary of the estimated plant investment is as follows:

Case		Plant investment $ (1977)
A	SCU plant only, granular urea from pan granulation	2,600,000
B	SCU plant plus small pan to make granular urea	3,680,000
C	SCU plant only, prilled urea from air-prilling tower	2,600,000

ESTIMATED PRODUCTION COSTS AND IN-PLANT PRICE

Costs for Raw Materials

Probable SCU production costs for a typical developing country, such as South Korea, are difficult to estimate because there is no firm information as to the value of uncoated fertilizer-grade urea in Korea or other developing countries nor are the values of sulfur and the sealant components known with any certainty. It would be virtually impossible to estimate their market values for 1977. The current estimated values are:

Item	Price, $/mt in or delivered to complex
Granular or prilled urea	150[a]
Elemental sulfur	65[b]
Sealant oil	150[b]
Sealant polyethylene	700[b]
Conditioner	50

[a]Assumed to be in-plant value, or price, excluding ex-plant sales, shipping and distribution costs; this value would be governed by competition with the landed price plus duties of imported urea.
[b]Assumed to be imported.

Production Costs and In-Plant Prices

The production costs and in-plant prices for bulk SCU given in Appendix tables A-1 (Case A), A-2 (Case B), and A-3 (Case C) are based on the above assumed values for the raw materials, based on fragmentary reports in early 1974. The calculations in the estimates are given in considerable detail as to requirements to permit later revision by the interested parties, based on their own estimate of the probable future values of these variables.

In Case B, in which the small pan-granulation unit is added to provide granular feed to the SCU unit, both the plant investment and the appropriate production costs of this unit were added to those of the SCU unit. However, it has been estimated previously by TVA that the operating costs for prilling and pan granulation are essentially the same, so that the only additional operating costs over and above those included in the transfer value of the urea to the SCU system would be the capital charges and the additional labor and maintenance required for the pan system. It is assumed that the normal urea synthesis and prill tower crew could not attend the pan system, which would be operating concurrently with the prill tower.

The estimated in-plant price is equal to the production cost per metric ton of SCU plus a 20% pretax return on total capital investment, including working capital. Sales expenses and overheads and transportation costs are *not* included in this calculated value. These values may be compared with the current estimated in-plant price of uncoated urea, namely, $150/mt. Under these conditions, the following relationships hold:

Product	Production cost, $/mt		In-plant price,[a] $/mt	
	Product	Nitrogen	Product	Nitrogen
SCU Case A (37% N)	149	402	159	430
SCU Case B (37% N)	154	416	167	452
SCU Case C (32% N)	141	441	151	472
Uncoated urea (46% N)	–	–	150	326

[a]Production cost plus 20% return on capital investment.

Thus, the estimated projected (1977) in-plant price of nitrogen from SCU in these small plants is 32% to 45% higher than the *current* price of nitrogen from uncoated urea. However, if the estimated current value of uncoated urea and other raw materials were escalated to 1977 on the same basis as were the capital costs of SCU (i.e., 10%/year), the in-plant price of SCU would be only 27% to 40% higher than the projected value of urea ($200/mt).

Development work on SCU is continuing at TVA and promising results have been obtained with a sulfur-only coating (no wax or conditioner). Although a somewhat heavier total coating is required [about 23% versus 20% for sealed SCU on granular urea (-6 +10 mesh)], it is potentially a less expensive process because of reduced plant investment and operating costs. It is estimated that such a product would cost only 20% more than uncoated

[2]Ratios are conventional scaling and cost escalation factors.

granular urea. However, the process has not been fully developed and the product has not been adequately tested in the field. Although some process difficulties have been encountered using this type of coating on prilled urea, it is believed that these can be solved and that proportionately reduced costs can be realized.

Advantages of SCU

In spite of the indicated premium for SCU, agronomic tests, generally with single applications of SCU, covering a period of over several years, have shown high benefit to cost ratios for such crops as rice (intermittent flooding), sugarcane, pineapple, watermelon, and tomatoes, when compared with multiple applications of uncoated urea. In addition, under climatic and soil conditions where leaching and/or volatilization are serious problems, SCU has shown measurable benefits even for short-term row crops. Also, SCU furnishes the essential plant nutrient, sulfur, an advantage for areas deficient in this nutrient; it eliminates damage to seeds and foliage by salt effect; it minimizes luxury consumption of nitrogen by the plant; and it is an excellent specialty fertilizer for turfs and ornamentals.

In addition to its agronomic advantages, SCU has a high resistance to moisture pickup and it is compatible with superphosphates.

Finally, in comparison with other types of controlled-release fertilizers, SCU is comparatively low in cost. For example, in the first quarter of 1974, the delivered price of ureaform was $315/mt in the United States. Delivered to a developing country, ureaform would be at least $340/mt, or about $900/mt of nitrogen, which is about twice the estimated price of SCU (N-basis) in the developing country.

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APPENDIX

Table A-1. Case A—Estimated 1977 production cost and in-plant price of sulfur-coated urea in an existing ammonia-urea complex having a pan-granulation unit

Plant capacity	200 mt/day	Plant investment	$2,600,000
	66,000 mt/year	Working capital[a]	622,000
Total capital investment			**$3,122,000**

Product grade 37-0-0-16S

	Unit/mt product	Cost, $/unit	Cost, $/mt product
Production costs			
Raw materials			
Sulfur	0.160	65	10.40
Sealant oil	0.015	150	2.25
Sealant polyethylene	0.005	700	3.50
Conditioner	0.020	50	1.00
Urea	0.800	150	120.00
Subtotal			137.15
Operating costs			
Operating labor, man-hr	0.32	5.00	1.60
Supervision, 15% operating labor			0.25
Maintenance, 5% plant investment			1.97
Electricity, kWh	10	0.02	0.20
Steam, 1,000 lbs	0.2	0.50	0.10
Supplies, 20% maintenance			0.40
Analyses, 20% labor			0.32
Plant overhead, 100% labor			1.60
Handling			0.50
Subtotal			6.94
Capital charges			
Depreciation, 6.7% (15-yr) plant investment			2.64
Insurance-taxes, 2% plant investment			0.79
Interest, 8% one-half plant investment			1.58
Subtotal			5.01
Subtotal production cost			149.10
Interest, 8% one-half working capital			0.38
Total production cost, $/mt SCU			**149.48**
Return on total capital investment, 20% pretax			9.50
In-plant price, $/mt			158.98
$/mt N			430.00

[a]Value of 90-day production inventory plus 30-day raw material inventory; transfer cost of urea is omitted because of its captive use.

Table A-2. Case B–Estimated 1977 production cost and in-plant price of sulfur-coated urea in an existing ammonia-urea complex having an added pan-granulation system

Plant capacity	200 mt/day	Plant investment	$3,680,000
	66,000 mt/yr	Working capital[a]	720,000
Total capital investment			**$4,400,000**

Product grade 37-0-0-16S

	Unit/mt product	Cost, $/unit	Cost, $/mt product
Production costs			
Raw materials			
Sulfur	0.160	65	10.40
Sealant oil	0.015	150	2.25
Sealant polyethylene	0.005	700	3.50
Conditioner	0.020	50	1.00
Urea	0.800	150	120.00
Subtotal			137.15
Operating costs[b]			
Operating labor, man-hrs	0.64	5.00	3.20[b]
Supervision, 15% operating labor			0.25
Maintenance, 5% plant investment			2.80[b]
Electricity, kWh	10	0.02	0.20
Steam, 1,000 lbs	0.2	0.50	0.10
Supplies, 20% maintenance			0.56[b]
Analyses, 20% labor			0.30
Plant overhead (same as Cases A, C)			1.60
Handling			0.50
Subtotal			9.51
Capital charges[b]			
Depreciation, 6.7% (15 yr) plant investment			3.74
Insurance-taxes, 2% plant investment			1.12
Interest, 8% one-half plant investment			2.24
Subtotal			7.10
Subtotal production cost			153.76
Interest, 8% one-half working capital			0.44
Total production cost, $/mt SCU			**154.19**
Return on total capital investment, 20% pretax			13.30
In-plant price, $/mt			167.49
$/mt N			452.00

[a]Value of 90-day production inventory plus 30-day raw material inventory; transfer cost of urea is omitted because of its captive use.
[b]Because of the incremental nature of this plant configuration, only labor, maintenance, maintenance supplies, and capital charges would increase over those of Case A.

Table A-3. Case C–Estimated 1977 production cost and in-plant price of sulfur-coated urea in an existing ammonia-urea complex having a prilling unit

Plant capacity	200 mt/day	Plant investment	$2,600,000
	66,000 mt/yr	Working capital[a]	775,000
Total capital investment			**$3,375,000**

Product grade 32-0-0-26S

	Unit/mt product	Cost, $/unit	Cost, $/mt product
Production costs			
Raw materials			
Sulfur	0.260	65	16.90
Sealant oil	0.015	150	2.25
Sealant polyethylene	0.005	700	3.50
Conditioner	0.020	50	1.00
Urea	0.700	150	105.00
Subtotal			128.65
Operating costs			
Operating labor, man-hrs	0.32	5.00	1.60
Supervision, 15% operating labor			0.25
Maintenance, 5% plant investment			1.97
Electricity, kWh	10	0.02	0.20
Steam, 1,000 lbs	0.2	0.50	0.10
Supplies, 20% maintenance			0.40
Analyses, 20% labor			0.32
Plant overhead, 100% labor			1.60
Handling			*0.50*
Subtotal			6.94
Capital charges			
Depreciation, 6.7% (15-yr) plant investment			2.64
Insurance-taxes, 2% plant investment			0.79
Interest, 8% one-half plant investment			1.58
Subtotal			5.01
Subtotal production cost			140.60
Interest, 8% one-half working capital			0.47
Total production cost, $/mt SCU			**141.17**
Return on total capital investment, 20% pretax			10.20
In-plant price, $/mt			151.37
$/mt N			472.00

[a]Value of 90-day production inventory plus 30-day raw material inventory; transfer cost of urea omitted because of its captive use.