Urea and Seed Coating Processes

Introduction

The assignment was to investigate the coating of urea with sulfur and the coating of seeds with pesticides and polymer. The former is a fertilizer, and the latter are seeds containing a controlled-release pesticide. The facility was to be capable of coating 100,000 ton/y of urea and 35,000 ton/y of seeds. Half of the seeds to be coated would be corn and the other half would be soybeans, based on the amount of corn and soybeans planted in the U.S.

An exhaustive analysis was conducted to determine the feasibility of this plant. The plant was divided into three different parts dedicated to each product. A "break-even" cost was calculated for each product based on the equipment used in the process and the amount of warehouse space dedicated to the product. The cost was then compared to current market prices for sulfur-coated urea, coated soybeans, and coated corn. The project was to be evaluated over a 10-year period at a hurdle rate of 15 %.

Results

The project was evaluated as three different processes: a sulfur-coated urea (SCU) process, a coated-corn seed process, and a coated-soybean seed process. A "break-even" cost was calculated for each of the three potential products, which was compared to typical market values in Table 1.

Table 1: Product costs compared to typical market values [1,2,3].

Product	Cost ($/50 lb. bag)	Competitor Cost ($/50 lb. bag)
SCU	$ 13.35	$ 28.97
Corn Seeds	$ 125.19	$ 134.50
Soybean Seeds	$ 36.51	$ 30.95

Urea

The process flow diagram for the production of sulfur-coated urea fertilizer can be found in Figure 1. The first step of the continuous process will involve heating the granular urea in a fluidized bed heater. The heat would aid in surface preparation of the granules to accept the subsequent coating of sulfur. The sulfur will then be applied in a rotary drum provided with lifting flights. As the granules pass through the coating drum, the sulfur coating will build up to 16% of the total weight. The material would be discharged into a sealant-coating drum where microcrystalline wax is applied (2 % of the total weight). The urea will then be cooled in a fluidized bed cooler. A conditioner such as talc will then be applied (2 % of the total weight) to the coated and cooled material.

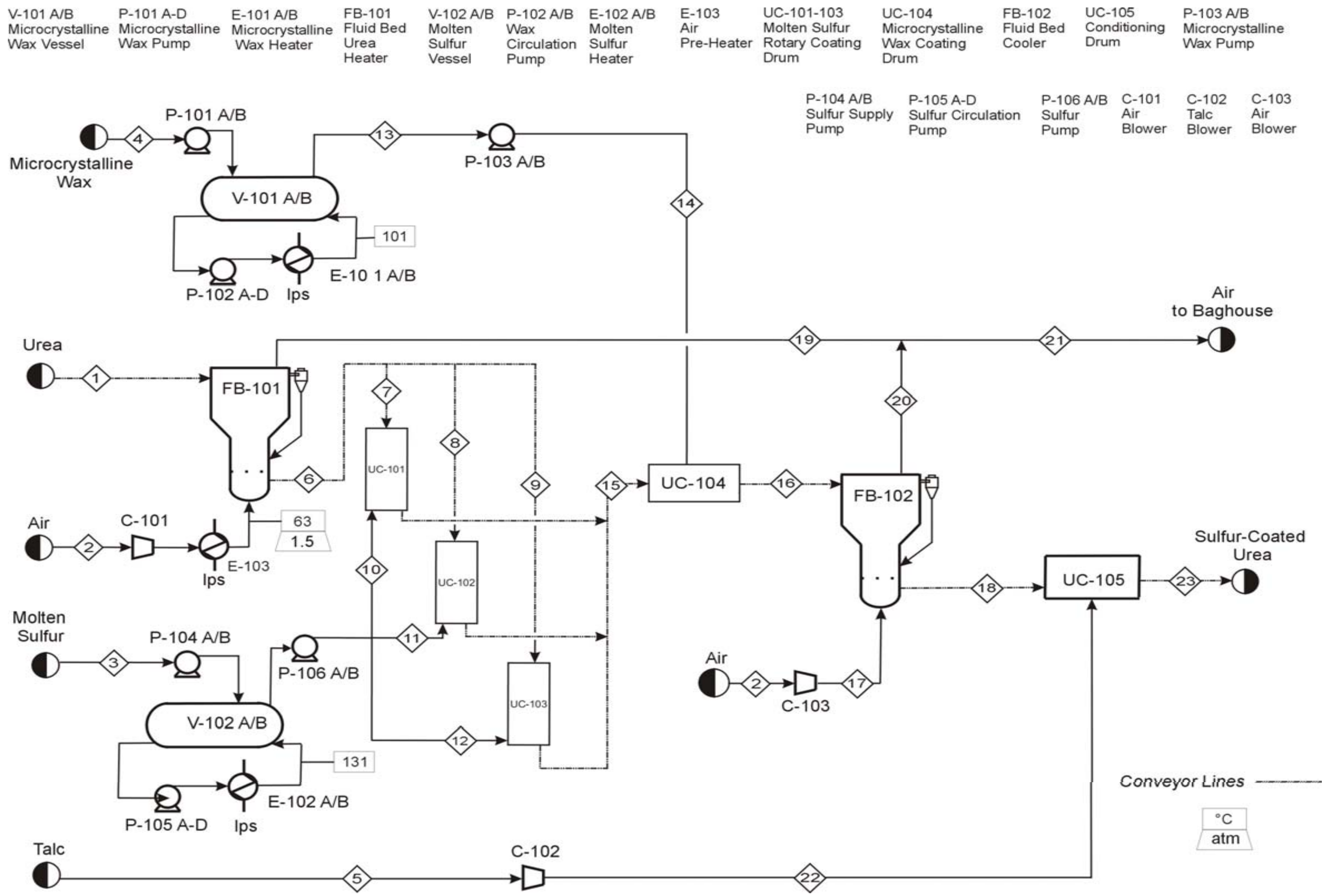

Figure 1: Sulfur-Coated Urea Process – Unit 100

The stream tables for the SCU process are presented in Table 2.

Table 2: Stream Tables for SCU Process – Unit 100

Stream No.	**1**	**2**	**3**	**4**	**5**	**6**
Temp °C	25	25	130	100	25	63
Pres atm	1	1	1	1	1	1
Total lb/h	25,000.00	156,888.00	4,000.00	500.00	500.00	25,000.00
Flowrates in lb/h						
Urea	25,000.00	0.00	0.00	0.00	0.00	25,000.00
Air	0.00	156,888.00	0.00	0.00	0.00	0.00
Sulfur	0.00	0.00	4,000.00	0.00	0.00	0.00
Microcrystalline Wax	0.00	0.00	0.00	500.00	0.00	0.00
Talc	0.00	0.00	0.00	0.00	500.00	0.00
Sulfur-Coated Urea	0.00	0.00	0.00	0.00	0.00	0.00
Sulfur/Wax–Coated Urea	0.00	0.00	0.00	0.00	0.00	0.00
Final Product	0.00	0.00	0.00	0.00	0.00	0.00

Stream No.	**7**	**8**	**9**	**10**	**11**	**12**
Temp °C	63	63	63	130	130	130
Pres atm	1	1	1	102	102	102
Total lb/h	8,333.33	8,333.33	8,333.33	1,333.33	1,333.33	1,333.33
Flowrates in lb/h						
Urea	8,333.33	8,333.33	8,333.33	0.00	0.00	0.00
Air	0.00	0.00	0.00	0.00	0.00	0.00
Sulfur	0.00	0.00	0.00	1,333.33	1,333.33	1,333.33
Microcrystalline Wax	0.00	0.00	0.00	0.00	0.00	0.00
Talc	0.00	0.00	0.00	0.00	0.00	0.00
Sulfur-Coated Urea	0.00	0.00	0.00	0.00	0.00	0.00
Sulfur/Wax–Coated Urea	0.00	0.00	0.00	0.00	0.00	0.00
Final Product	0.00	0.00	0.00	0.00	0.00	0.00

Table 2: Stream Tables for SCU Process – Unit 100 (cont.)

Stream No.	**13**	**14**	**15**	**16**	**17**	**18**
Temp °C	100	100	74	71	21	38
Pres atm	1	102	1	1	1.4	1
Total lb/h	500.00	500.00	29,000.00	29,500.00	120,224.00	29,500.00
Flowrates in lb/h						
Urea	0.00	0.00	0.00	0.00	0.00	0.00
Air	0.00	0.00	0.00	0.00	120,224.00	0.00
Sulfur	0.00	0.00	0.00	0.00	0.00	0.00
Microcrystalline Wax	500.00	500.00	0.00	0.00	0.00	0.00
Talc	0.00	0.00	0.00	0.00	0.00	0.00
Sulfur-Coated Urea	0.00	0.00	29,000.00	0.00	0.00	0.00
Sulfur/Wax–Coated Urea	0.00	0.00	0.00	29,500.00	0.00	29,500.00
Final Product	0.00	0.00	0.00	0.00	0.00	0.00

Stream No.	**19**	**20**	**21**	**22**	**23**
Temp °C	63	38	44	25	25
Pres atm	1	1	1	1	1
Total lb/h	36,464.00	120,224.00	156,888.00	500.00	30,000.00
Flowrates in lb/h					
Urea	0.00	0.00	0.00	0.00	0.00
Air	36,464.00	120,224.00	156,888.00	0.00	0.00
Sulfur	0.00	0.00	0.00	0.00	0.00
Microcrystalline Wax	0.00	0.00	0.00	0.00	0.00
Talc	0.00	0.00	0.00	500.00	0.00
Sulfur-Coated Urea	0.00	0.00	0.00	0.00	0.00
Sulfur/Wax–Coated Urea	0.00	0.00	0.00	0.00	0.00
Final Product	0.00	0.00	0.00	0.00	30,000.00

An equipment breakdown for the SCU process is displayed in Table 3, including the installed cost for each item.

Table 3: Equipment and Investment Summary for SCU process

Pumps

P-101 A/B Carbon Steel – Centrifugal Actual Power: 0.37 kW Efficiency: 80 % Installed Cost: $ 23,300	**P-102 A-D** Carbon Steel – Centrifugal Actual Power: 0.97 kW Efficiency: 80 % Installed Cost: $ 46,700
P-103 A/B Carbon Steel – Centrifugal Actual Power: 0.82 kW Efficiency: 80 % Installed Cost: $ 23,300	**P-104 A/B** Carbon Steel – Centrifugal Actual Power: 0.37 kW Efficiency: 80 % Installed Cost: $ 23,300
P-105 A-D Carbon Steel – Centrifugal Actual Power: 0.52 kW Efficiency: 80 % Installed Cost: $ 46,700	**P-106 A/B** Carbon Steel – Centrifugal Actual Power: 3.73 kW Efficiency: 80 % Installed Cost: $ 44,800

Vessels

V-101 A/B Maximum Operating Pressure: 200 kPa Diameter: 3.96 m Height: 4.82 m Volume: 59.5 m^3 Installed Cost: $ 55,700 ea.	**V-102 A/B** Maximum Operating Pressure: 200 kPa Diameter: 3.96 m Height: 4.82 m Volume: 59.5 m^3 Installed Cost: $ 55,700 ea.

Heat Exchangers

E-101 A/B Area: 11 m^2 1-2 exchanger, Fixed Head, Carbon Steel Installed Cost: $ 121,000	**E-102 A/B** Area: 11 m^2 1-2 exchanger, Fixed Head, Carbon Steel Installed Cost: $ 121,000
E-103 Area: 140 m^2 1-2 exchanger, Fixed Head, Carbon Steel Installed Cost: $ 105,000	

Table 3: Equipment and Investment Summary for SCU process (cont.)

Urea Coaters

UC-101 Length: 3.4 m Diameter: 1.5 m Power: 1.74 kW Installed Cost: $ 90,000	**UC-102** Length: 3.4 m Diameter: 1.5 m Power: 1.74 kW Installed Cost: $ 90,000
UC-103 Length: 3.4 m Diameter:1.5 m Power: 1.74 kW Installed Cost: $ 90,000	**UC-104** Length: 2.7 m Diameter: 1.2 m Power: 1.74 kW Installed Cost: $ 90,000
UC-105 Length: 2.5 m Diameter: 1.5 m Power: 1.74 kW Installed Cost: $ 90,000	**Talc Delivery System** Installed Cost: $ 60,000

Fluidized Beds

FB-101 Height: 2.8 m Diameter: 1.1 m Installed Cost: $ 29,900	**FB-102** Height: 4.6 m Diameter: 1.8 m Installed Cost: $ 75,700

Blowers

C-101 Power: 302 kW Efficiency: 80 % Installed Cost: $ 29,100	**C-102** Power: 0.764 kW Included with Talc Delivery System
C-103 Power: 255 kW Efficiency: 80 % Installed Cost: $ 26,000	**Conveyor Motor** Power: 9.70 kW Installed Cost: $ 15,000

The manufacturing costs breakdown for the SCU process is illustrated in Table 4. The process “break-even” cost can be found in Table 1.

Table 4: Manufacturing Cost Summary for SCU Process

Economic Factors	**Cost ($/yr)**
Product Sales	-$ 63,000,000
Raw Materials	$ 45,000,000
Steam	$ 231,000
Electricity	$ 1,800,000
Equipment Cost	$ 810,000
Warehouse Cost	$ 2,770,000
Labor	$ 6,900,000

<u>Corn</u>

The process utilized in the coating of corn will consist of two rotary coating drums. In the first drum, the corn would be coated with a fungicide (Captan®) and a pesticide (Poncho® 1250), which protects the seed from environmental pests. In the second coating drum, a temperature-switch polymer would be coated on the seed, which allows the seed to germinate only after the weather is suitable. The seeds will then be sent to packaging. This process is illustrated in Figure 2.

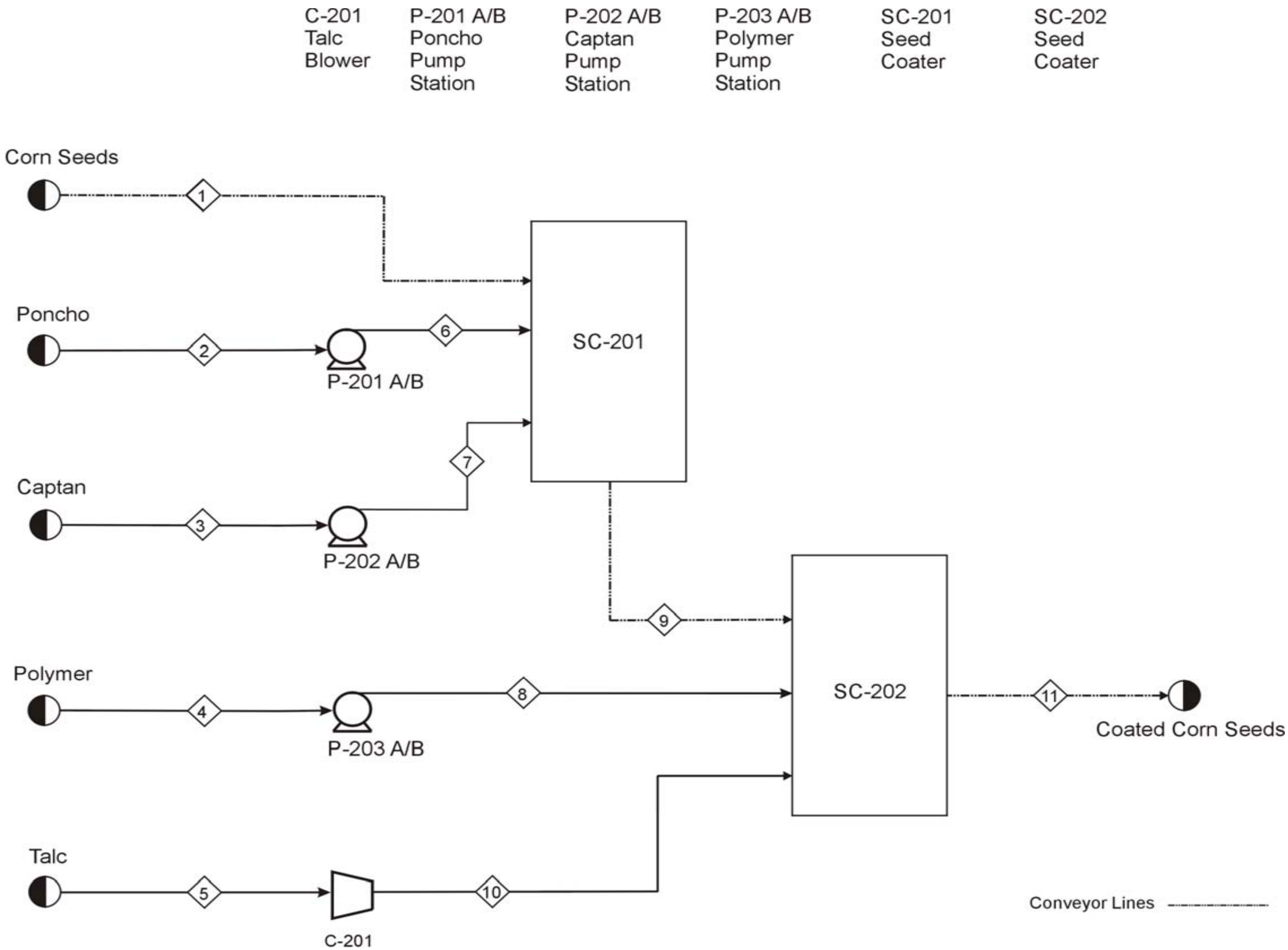

Figure 2: Corn-Coating Process – Unit 200

The stream tables for the corn-coating process are given in Table 5.

Table 5: Stream Tables for Corn-Coating Process – Unit 200

Stream No.	**1**	**2**	**3**	**4**	**5**
Temp °C	25	25	25	0	25
Pres atm	1	1	1	1	1
Total lb/hr	18,229.00	167.23	14.46	2.13	364.58
Corn Seeds	18,229.00	0.00	0.00	0.0	0.00
Poncho	0.00	167.23	0.00	0.00	0.00
Captan®	0.00	0.00	14.46	0.00	0.00
Polymer	0.00	0.00	0.00	2.13	0.00
Talc	0.00	0.00	0.00	0.00	364.58
Pest. Coated Seed	0.00	0.00	0.00	0.00	0.00
Final Coated Seed	0.00	0.00	0.00	0.00	0.00

Stream No.	**6**	**7**	**8**	**9**	**10**
Temp °C	25	25	0	25	25
Pres atm	100	100	100	1	1
Total lb/hr	167.23	14.46	3.55	18,410.69	364.58
Corn Seeds	167.23	0.00	0.00	0.00	0.00
Poncho	0.00	0.00	0.00	0.00	0.00
Captan®	0.00	14.46	0.00	0.00	0.00
Polymer	0.00	0.00	3.55	0.00	0.00
Talc	0.00	0.00	0.00	0.00	364.58
Pest. Coated Seed	0.00	0.00	0.00	18,410.69	0.00
Final Coated Seed	0.00	0.00	0.00	0.00	0.00

Stream No.	**11**
Temp °C	25
Pres atm	1
Total lb/hr	18,777.40
Corn Seeds	0.00
Poncho	0.00
Captan®	0.00
Polymer	0.00
Talc	0.00
Pest. Coated Seed	0.00
Final Coated Seed	18,777.40

A detailed equipment summary for the corn-coating process is presented in Table 6, along with the cost breakdown each piece of equipment.

Table 6: Equipment and Investment Summary for corn-coating process

SC-201 Gustafson CBT-200 System Power: 1.5 kW Includes P-201 A/B and P-202 A/B Installed Cost: $ 495,000	**SC-202** Gustafson CBT-200 System Power: 1.5 kW Includes P-203 A/B and Talc Delivery System Installed Cost: $ 495,000
SP-201 Super Sack Packaging Equipment Power: 2.3 kW Installed Cost: $ 72,000	**SP-202** 50 lb Bag Packaging System Power: 2.3 kW Installed Cost: $ 600,000
Talc Delivery System Installed Cost: $ 60,000	**C-201** Power: 0.764 kW Installed Cost: Included in Talc Delivery System
V-201 A-E Corn Seed Storage Bins Height: 40 ft. Diameter: 13 ft. Installed Cost: $ 72,000 ea.	Conveyor Motor Power: 3.73 kW Installed Cost: $ 15,000

The breakdown of manufacturing costs for the corn-coating process is displayed in Table 7. The process "break-even" cost can be found in Table 1.

Table 7: Manufacturing Cost Summary for Corn-Coating Process

Economic Factors	**Cost ($/yr)**
Product Sales	-$ 88,000,000
Raw Materials	$ 81,000,000
Electricity	$ 173,000
Equipment Cost	$ 445,000
Warehouse Cost	$ 1,820,000
Labor	$ 403,000

Soybeans

The soybean-coating process will differ slightly from the process used to coat corn. In this process, only two coatings would be applied. In the first coating drum, a pesticide (Gaucho®) will be added to protect the seed from insects that may be found in the soil. The second coating is the temperature-switch polymer, which prevents early germination. The soybean coating process is illustrated in Figure 3.

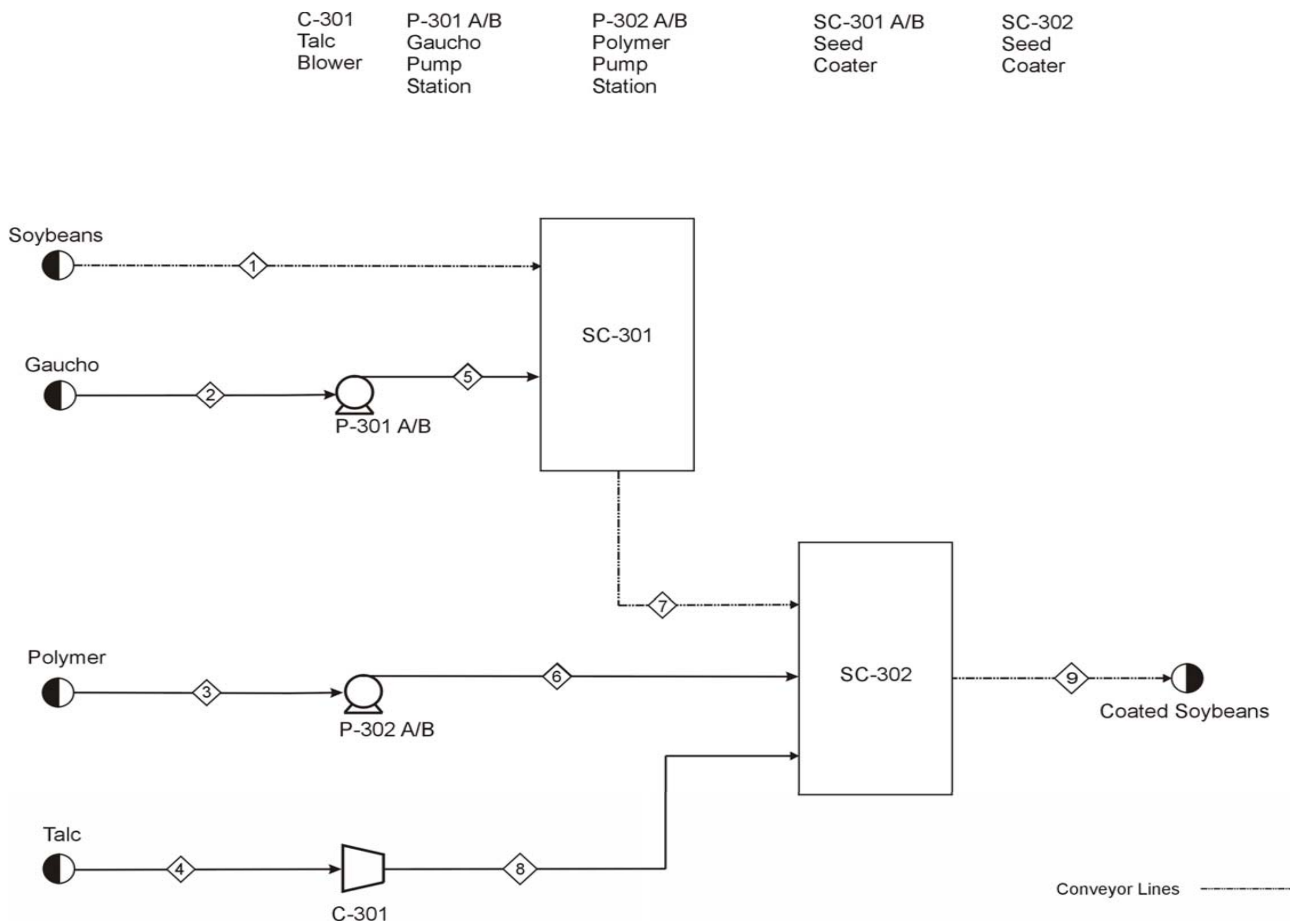

Figure 3: Soybean-Coating Process – Unit 300

The stream tables for the soybean-coating process are given in Table 8.

Table 8: Stream Tables for Soybean-Coating Process – Unit 300

Stream No.	**1**	**2**	**3**	**4**	**5**
Temp °C	25	25	0	25	25
Pres atm	1	1	1	1	100
Total lb/hr	12153	24.20	1.42	243.06	24.20
Soybeans	12153	0.00	0.00	0.00	0
Gaucho	0.00	24.20	0.00	0.00	24.20
Polymer	0.00	0.00	1.42	0.00	0.00
Talc	0.00	0.00	0.00	243.06	0.00
Pest. Coated Seed	0.00	0.00	0.00	0.00	0.00
Final Coated Seed	0.00	0.00	0.00	0.00	0.00

Stream No.	**6**	**7**	**8**	**9**
Temp °C	25	25	25	25
Pres atm	100	1	1	1
Total lb/hr	1.42	12,176.98	243.06	12,421.46
Soybeans	0.00	0.00	0.00	0.00
Gaucho	0.00	0.00	0.00	0.00
Polymer	1.42	0.00	0.00	0.00
Talc	0.00	0.00	243.06	0.00
Pest. Coated Seed	0.00	12,176.98	0.00	0.00
Final Coated Seed	0.00	0.00	0.00	12,421.46

A detailed equipment and investment summary for the soybean-coating process is presented in Table 9.

Table 9: Equipment and Investment Summary for Soybean-coating process

SC-301 Gustafson CBT-200 System Power: 1.5 kW Includes P-301 A/B Installed Cost: $ 495,000	**SC-302** Gustafson CBT-200 System Power: 1.5 kW Includes P-302 A/B and Talc Delivery System Installed Cost: $ 495,000
SP-301 Super Sack Packaging Equipment Power: 2.3 kW Installed Cost: $ 72,000	**SP-302** 50 lb Bag Packaging System Power: 2.3 kW Installed Cost: $ 600,000
Talc Delivery System Installed Cost: $ 60,000	**C-301** Power: 0.764 kW Installed Cost: Included in Talc Delivery System
V-301 A-E Soybean Seed Storage Bins Height: 12.2 m Diameter: 4.0 m Installed Cost: $ 72,000 ea.	**Conveyor Motor** Power: 3.73 kW Installed Cost: $ 15,000

Finally, the manufacturing costs breakdown for the soybean-coating process is presented in Table 10. The process "break-even" cost can be found in Table 1.

Table 10: Manufacturing Cost Summary for Soybean-Coating Process

Economic Factors	**Cost ($/yr)**
Product Sales	-$ 26,600,000
Raw Materials	$ 20,700,000
Electricity	$ 172,000
Equipment Cost	$ 445,000
Warehouse Cost	$ 1,140,000
Labor	$ 607,000

In addition to the aforementioned equipment, there is also equipment to be shared by all three processes. This equipment cost will be distributed among the three processes based on the amount of area dedicated to each process in the facility. The SCU process will account for 44 % of the area and the soybean and corn-coating processes each occupy 28 % of the area. A summary of this equipment can be found in Table 11.

Table 11: Miscellaneous Process Equipment and Expenses

HVAC Installed Cost: $ 1,710,000	**Building** Cost: $ 11,075,000
Shelving Installed Cost: $ 55,000	**Forklift Trucks (14)** Cost: $ 364,000

Production Scheduling

The production schedules for seed coating must be balanced in order to produce the required amount of seeds. Figure 4 shows the times to be allotted for coating each seed as well as the times for purchase and sale of the seed product. A detailed explanation of why this production schedule was chosen is given in the following section.

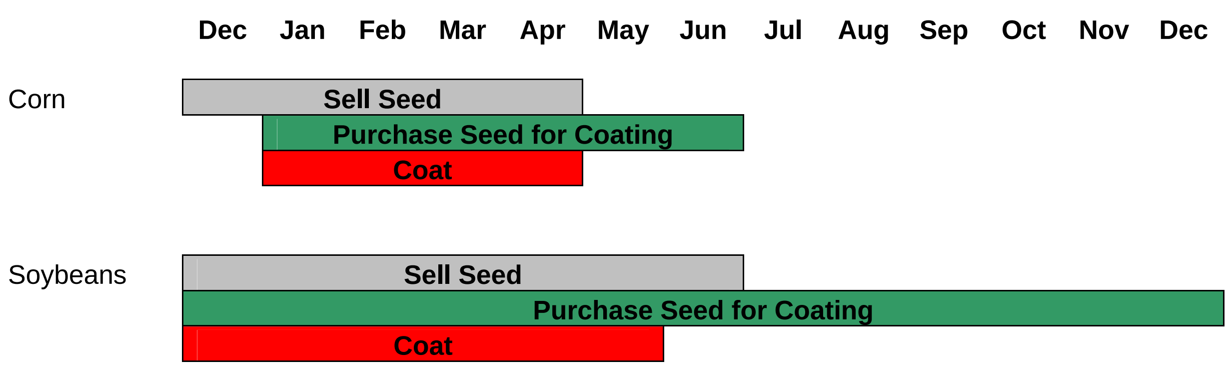

Figure 4: Production Scheduling for Seeds

Warehouse Design

It is suggested the final production facility be located in southern Iowa. This locale is chosen because it is near major corn and soybean demand areas and is also near the chosen molten sulfur supplier. The facility will utilize a 3.5 acre building space. A ten-acre lot is to be purchased at \$10,000/acre to accommodate the manufacturing building, parking areas, shipping and receiving lots, and any future building expansions that may occur [4]. An overview of the production facility is shown as Figure 5. The employee facilities consist of all offices, locker rooms, cafeterias, and other required managerial spaces. This area is adjacent to a plant personnel parking lot. The employee facilities area is 140 ft by 96 ft, totaling 13,440 ft^2.

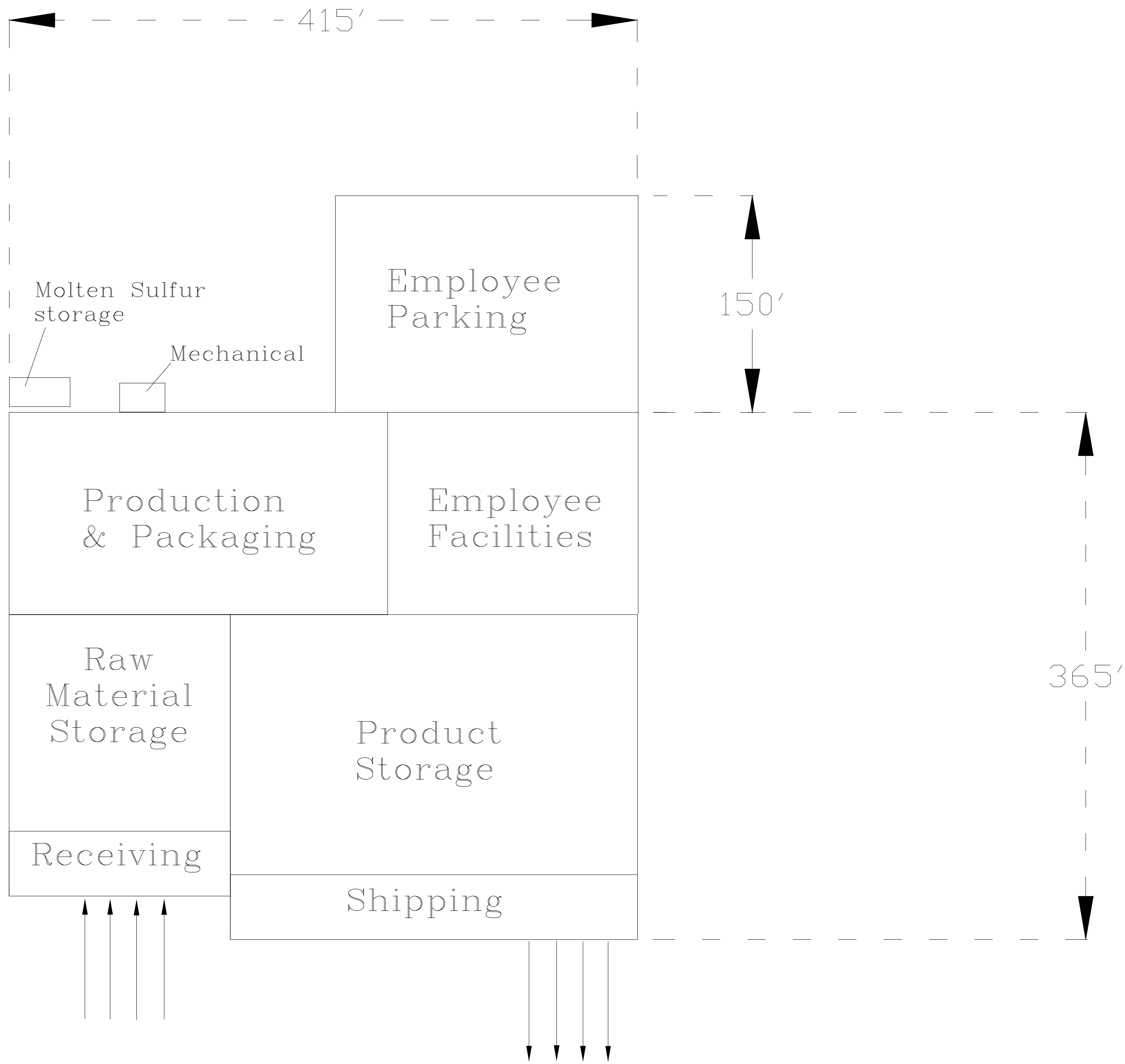

Figure 5: Facility Layout

Receiving/Raw Material Storage Area

The urea supplier is Transammonia Inc. The urea is purchased for $325/ton including shipping costs and will be imported to the facility by railcar. A railcar can hold 100 tons of material; therefore, in order to meet production demands, three railcars per day will be required.

Corn and soybeans will both be received by truck. A single grain truck will normally have a 25-ton capacity. The corn seed will be supplied by Dahlco Seed Co. at $2,940/ton. This company only supplies corn during the spring of the year as a result of harvest dates; therefore, corn will only be coated during four months of the year. In order to meet production requirements, three trucks per day will be required.

Soybeans will be delivered by Renk Seed Co. at $720/ton. The shipment originates in Prairie, Wisconsin, and can be supplied continuously throughout the year. However, to reduce product storage time, soybeans will only be coated during the first six months of the year when soybeans are sold for planting. To meet production requirements, two seed trucks per day will be required for soybeans.

The receiving area of the production facility consists of four separate truck-unloading bays designed to handle corn, soybean, pesticide, and coatings delivery. The majority of truck deliveries will be for corn and soybeans. When the urea, corn, and soybean raw material are delivered to the facility, they will be transported first by a bulk material handling system. The system will begin with a truck unloading station, where a large truck will be able to dump its contents. The system can be adapted for railcar usage and be environmentally controlled if needed. In order to prevent contamination, a separate unloading station will be used for seeds and urea. The material will then be unloaded into a collection hopper at or below ground level.

From this hopper, the raw material can be vertically augered to a point called the "Holding Container Selector."

The "Holding Container Selector" is a point vertically located above the holding bins such that the potential energy of the material can be utilized for final destination delivery. At this point, the material is separated from the auger and has the option to fall in a number of directions. Through the use of valves, the material can then be directed to a specified bin. The material will then fall down a chute and into the container of choice.

The bin should be located in an environmentally controlled area. Each bin would be constructed of metal. Another important trait of the system is that batches can be kept separate, and the material can be used in the order of arrival to the facility. Each bin will have the ability to gravity feed a conveyor belt to take the material to the production line. To control flow from a bin, a set of slide valves will be attached to the outlet. The slide valves, attached to powerful hydraulic rams, will be used to open or close the outlet hole. Figures 6 and 7 show the bulk material handling system.

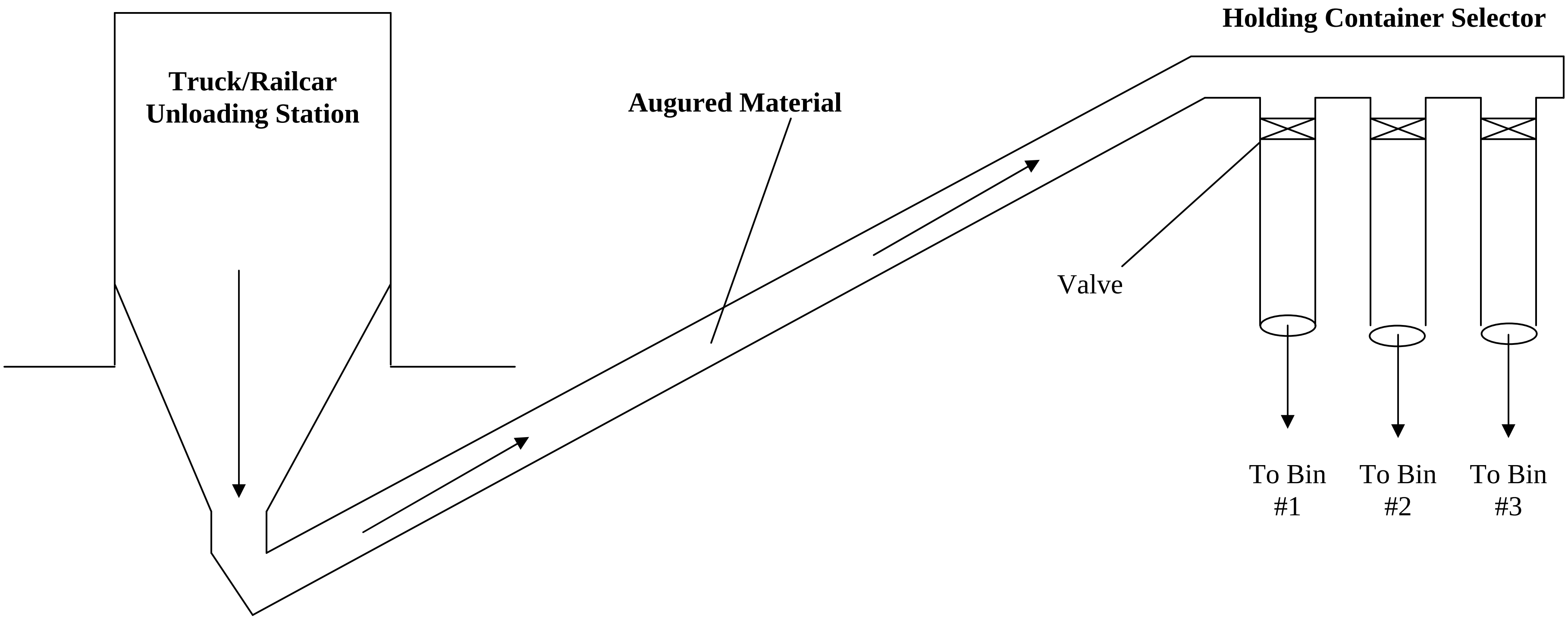

Figure 6: Bulk Material Handling System

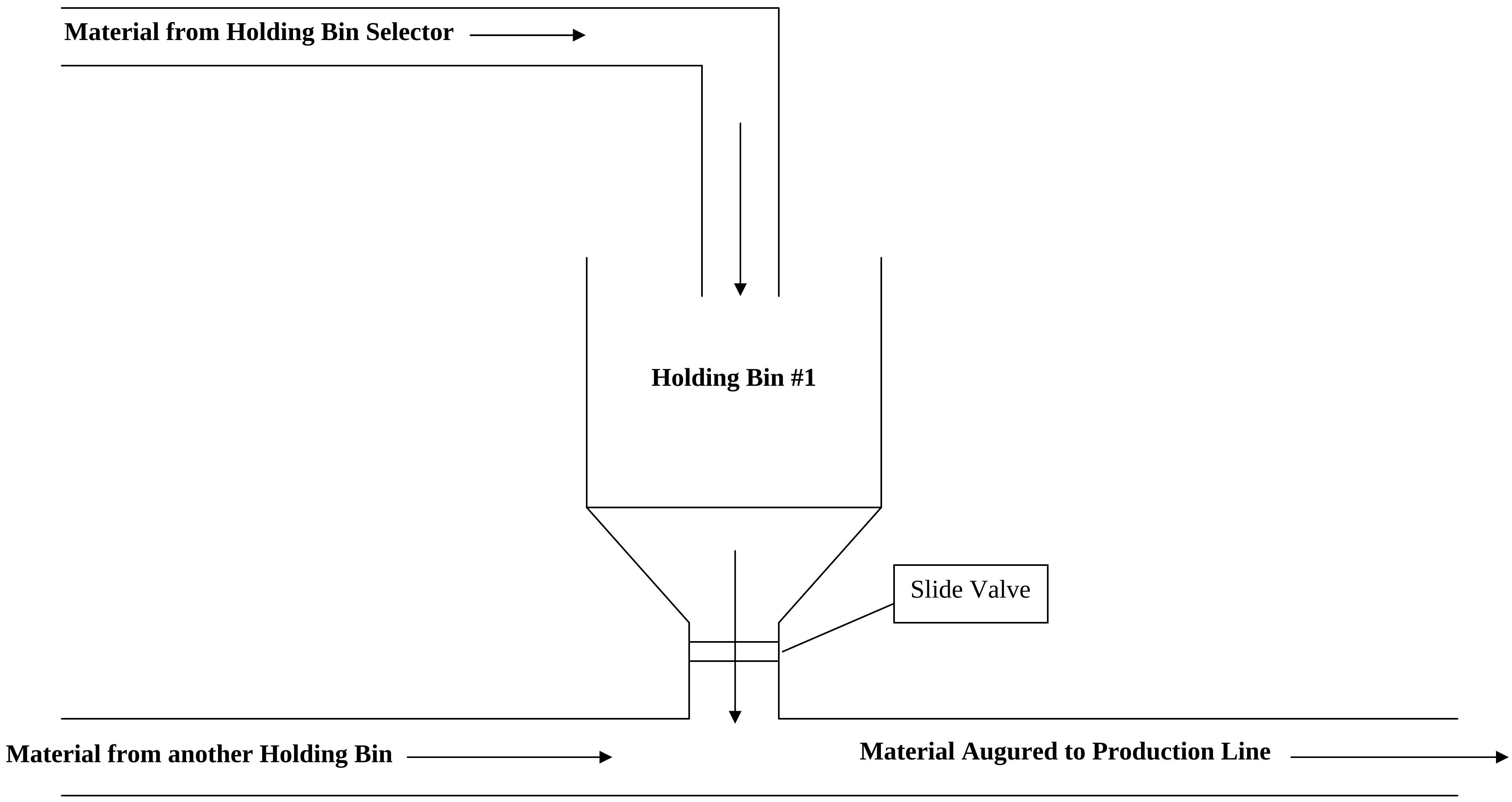

Figure 7: Bulk Material Handling System inside Storage Area

Once the bulk seed and urea raw materials are inside the facility, they will be stored in an area controlled for temperature and humidity. Each of these materials is negatively affected in the presence of a high-moisture environment. Urea is highly hygroscopic; therefore, to prevent unwanted handling problems due to moisture absorption, urea will be kept in a controlled-humidity environment. Over time, corn and soybeans can both degrade or germinate if kept in an area with too high moisture content or an area with an exceedingly high temperature. As a result, the storage area for both types of seed will be controlled with respect to temperature and humidity. The temperature and humidity controlled area will be regulated to a relative humidity of 10% and an average temperature of 50°F. A storage period of one week is suggested in order to minimize storage requirements but still have a surplus of raw material in case of a problem with reception of more raw materials. All urea and seed bulk material will be sent to the production line for coating by way of conveyors. Each storage bin will be able to dispense the necessary raw material directly onto a moving conveyor. The layout for the raw material storage area is shown in Figure 8.

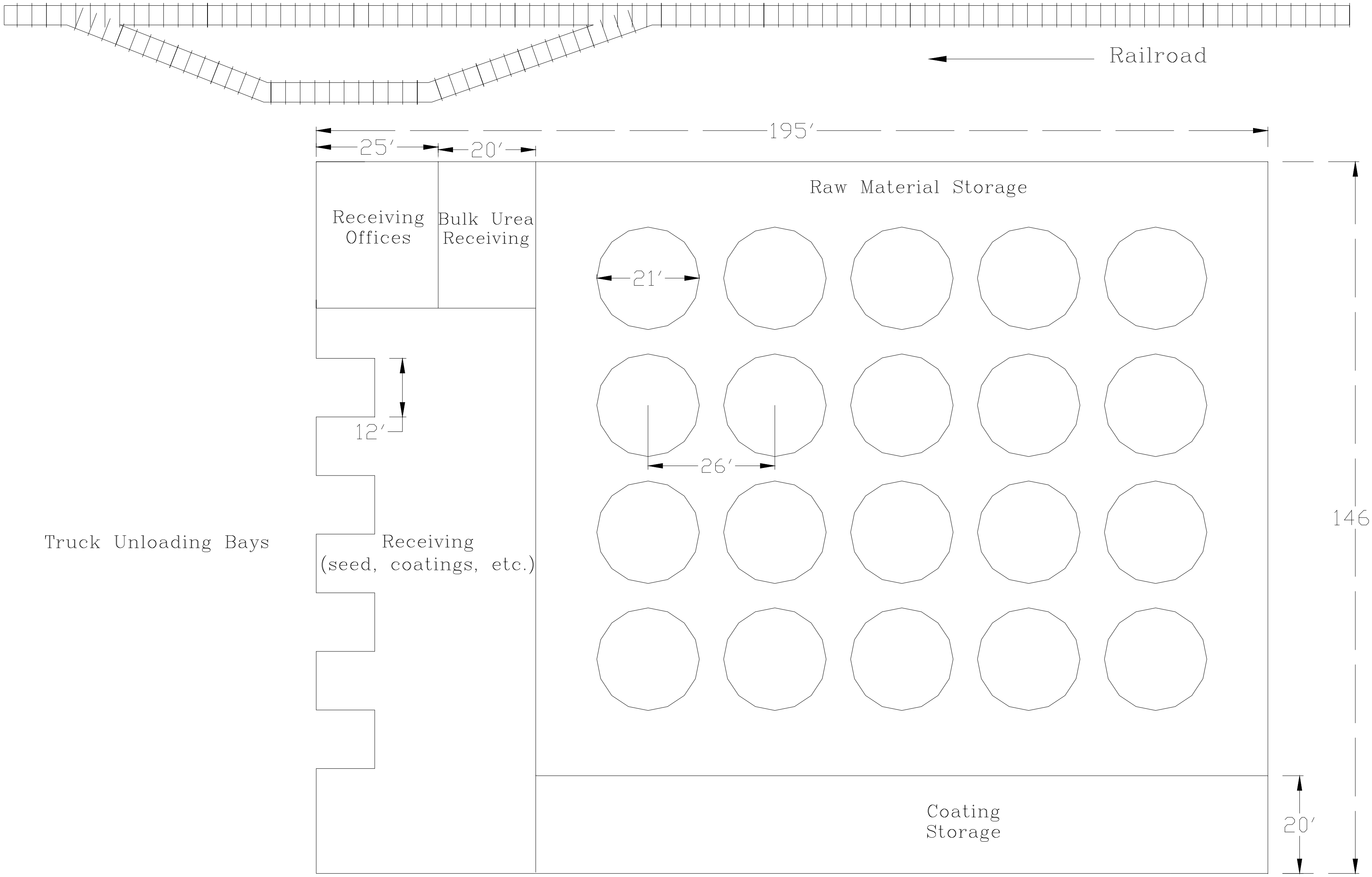

Figure 8: Raw Material Storage/Receiving Area

Production Area

The molten sulfur needed for urea coating will be stored in a building adjacent to the production area but segregated from the main facility. This is suggested to minimize railcar unloading problems and also to isolate sulfur's unpleasant odor from the rest of the facility. Molten sulfur will be stored in two separate storage tanks, 2,100 ft^3 in size. The sulfur will need to remain between 120°C and 190°C in order to stay in the molten state. At temperatures below 120°C, sulfur solidifies because it is below its melting point. Above 190°C, sulfur will become too viscous to pump due to polymerization problems. As a result of the strict temperature requirements on sulfur storage, all molten sulfur storage vessels will be well insulated and continuously heated by a pump and heat exchanger recycle loop.

The production area of the facility is the area where all coating and packaging operations are performed. The seed and urea coating area is 250 ft by 140 ft totaling an area of 35,000 ft^2. The urea production area is slightly larger than the corn and soybean area due to an increase in equipment necessary to coat urea properly. The corn and soybean coating areas are equally spaced because both processes are essentially identical in terms of process equipment.

The packaging area utilizes a 1,200 lb bulk Super Sack loader, as well as a continuous 50 lb. bag loader for each coating process. The bulk Super Sack loaders will process up to 20 bags/hr, while the 50 lb bag loader will process up to 120 bags/hr dependent upon the process. A summary of packaging rates for each process is shown in Table 12.

Table 12: Packaging Rates for each Process

Process	**Super Sack Packaging Rate (bags/hr)**	**50 Lb. Bag Packaging Rate (bags/hr)**
Urea	20	118
Corn	4	338
Soybean	2	226

After the final coated product is packaged, it will be sent to the product storage area. The layout for the production and packaging area is shown in Figure 9.

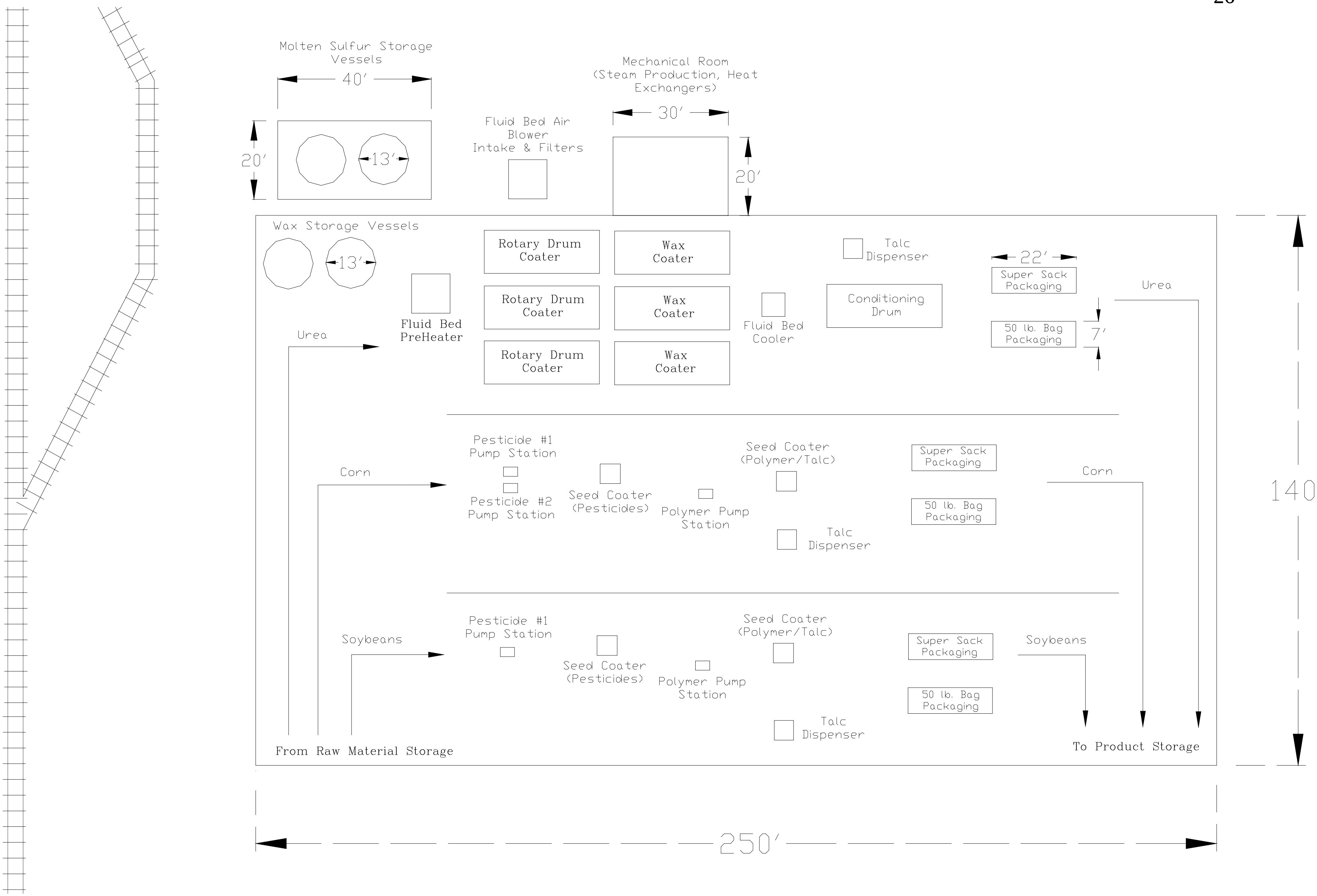

Figure 9: Production and Packaging Layout

Product Storage Area

The product storage area is designed to hold one week of packaged material. It is not controlled for temperature and humidity in the same manner as the raw material storage, because the coating and packaging process negates any harmful reactions that may occur. The product storage area will utilize a shelving system designed to hold five palettes high, while a single palette holds one ton of product. The shipping dock consists of four truck-shipping bays to remove product easily from the facility. The product storage area is 269 ft by 225 ft, giving a total area of 60,525 ft^2. The layout of the product storage area is shown in Figure 10.

Figure 10: Product Storage Area

<u>Facility Building Cost Breakdown</u>

An overall comparison of the costs associated with each area of the production facility has been evaluated. The facility has been priced by using the highest suggested price per square foot according to the 1996 International Construction Cost and Reference Data Yearbook [5]. The Chemical Engineering Plant Cost Index was used to bring the cost of the warehouse to a present day cost. The storage areas were priced as warehouse/distribution centers, employee facilities were priced as an office building, and the production area was priced as an industrial building/factory. The results of this comparison are shown in Table 13.

Table 13: Building Costs Based on Area

	Cost per ft^2	**Cost ($)**	**Percentage of Building Cost**
Raw Material Storage Area	55.8	$2,073,000	18.6%
Production/Packaging Area	81.8	$2,872,400	25.8%
Product Storage Area	55.8	$3,467,400	31.1%
Employee Facilities	114.1	$2,642,600	23.7%
Molten Sulfur Storage	55.8	$44,800	0.4%
Mechanical Area	55.8	$33,600	0.3%
Total		**$11,133,800**	

Because the production process will be producing three different products in the same building, it is necessary to break down the facility building cost for each individual process. Coated urea is produced at the highest flow rate; therefore, it consists of the largest portion of the raw and product storage areas. As a result, the building area associated with urea production comprises 43.3% of the total building cost. The results of this breakdown are shown in Figure 11. The total building cost has been calculated at $11.1 million.

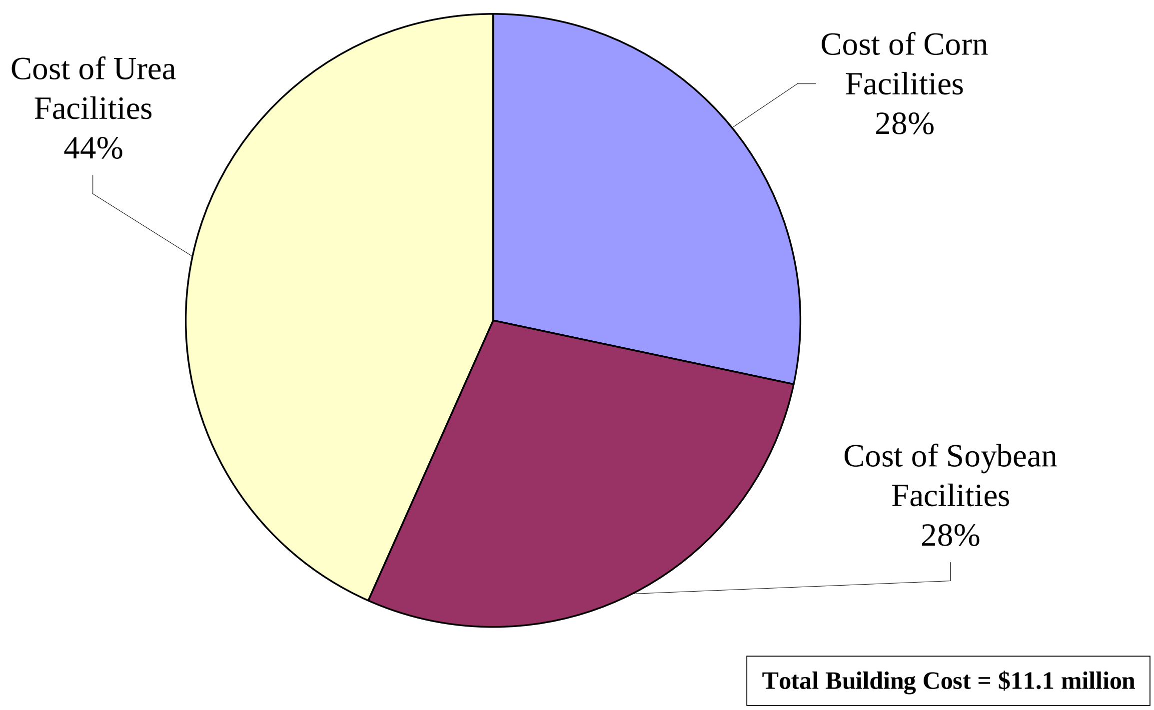

Figure 11: Breakdown of Building Costs

The raw material storage area is one area of the facility that can vary in size depending on the amount of raw material kept on hand at one time. The cost of the raw material storage area will change with the number of days required for storage. As a result, the break-even price for all material will change depending on the raw material stored. A summary of several different storage time periods is shown in Table 14. One week of storage is recommended to allow for flexibility and to prevent the cost of the warehouse from becoming to large.

Table 14: Raw Material Storage effect on Break Even Price

	Break Even Price ($/50 lb. bag)		
Storage Time	**Urea**	**Corn**	**Soybean**
3 days	$13.13	$123.60	$35.38
1 week	**$13.35**	**$125.19**	**$36.51**
2 weeks	$13.75	$127.91	$38.10
1 month	$14.60	$133.81	$41.73

Conclusions

It is recommended that three products for production: corn seed coated with Poncho® and a temperature-switch polymer, soybean seed coated with Gaucho® and a temperature-switch polymer, and urea coated with sulfur. All of the prices calculated are competitive with respect to typical market values. Also, some of the products may be sold at higher prices to aid in the reduction of the cost of other products. It is recommended to build this facility that consists of three production lines.

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