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The U.S. Formula Feed Industry Today

Wayne Anderson
Feedstuffs Senior Editor

The one sure statement that can be made about the formula feed industry in the U.S. today is that it will not be the same tomorrow. Change has always been a part of feed manufacturing, as with most other industries, and that is as true now as it has ever been. New customers, new markets, new technology, and different economic conditions all play roles in causing that change.

The U.S. feed industry of the 1980's is basically a mature industry. Overall, per capita consumption of animal products has generally plateaued and population growth in the U.S. has stabilized at an annual rate of about 1%. Livestock and poultry producers continue to decline in numbers while increasing in unit size. The growth of various forms of vertical integration, contractual arrangements and, more recently, on-farm feed mixing, all have combined with fewer customers to cause a decline in the number of manufacturers and dealers in the traditional formula feed industry in the U.S.

Defining the Industry

When doing any survey of the feed industry, it is necessary to set up definable parameters to which the feed manufacturers and their products can be compared. The United States Department of Agriculture has periodically conducted surveys of the feed industry. In those studies the following definitions for feed manufacturing have been used:

- *Feed-milling establishment* is usually a stationary mill operation at a single location together with any mobile mills based at that location.
- *Primary feed manufacturing* is the processing and mixing of individual feed ingredients, sometimes with the addition of a premix at a rate of less than 100 pounds per ton of finished feed.
- *Secondary feed manufacturing* is the processing and mixing of one or more ingredients with formula feed supplements. Supplements are usually used at a rate of 300 pounds or more per ton of finished feed, depending on the protein content of the supplement and percentage of protein desired in the finished feed.
- *Custom grinding and mixing* is grinding customer-owned feed ingredients and usually mixing supplements with them. Mainly, this is a service provided to farmers feeding their own animals.

One of the major problems involved in evaluating the production figures of the feed industry is a lack of clear definition of types of feeds. However, the American Feed Manufacturers Association has defined types of feeds in the following manner:

- *Complete feed* contains a proper balance of nutrients and is intended to be the sole ration for nonruminant rations. Roughage is normally excluded from complete feed. However, for ruminant animals some portion of the roughage needs may be included in the complete commercial ration.
- *Supplements/concentrates* contain the proper balance of protein, vitamins, minerals, trace minerals, and additives. It is added with grain and/or roughage at the rate of approxi-

mately 200 pounds or more per ton to make a balanced ration.

- *Base mixes/super concentrates* differ from supplements in that they contain only part of the animal's protein requirements. It is added with grain and other high protein ingredients at the rate of 100 pounds (or more) per ton to make a balanced ration.
- *Premixes* are formulations of one or more microingredients, such as vitamins, minerals, trace minerals, or drugs mixed with a carrier ingredient. They do not contain any significant amount of protein. A premix is usually added at a rate of less than 100 pounds per ton with grain and other protein ingredients to make a balanced ration for nonruminant animals. For beef, it may be mixed (or top-dressed) with grains and/or roughages to make a complete ration.

The feed industry has traditionally been an outlet for a number of mill by-products and oil extraction products. Table 2-1 illustrates how certain by-product ingredients have increased in usage over the past 15 years. Compiled by USDA, the table shows a dramatic increase in demand for soybean meal while other protein ingredients have either held steady or have declined. Additionally, the quantity of high-protein feeds consumed by livestock and poultry has increased greatly.

Corn is the primary grain used in animal feeds in the U.S., comprising about 75% of the feed grain market for domestic consumption (Table 2-2). In terms of corn equivalents, feed consumed by livestock and poultry showed little growth in the early 1980's; in fact, consumption has not grown to a great degree over the last 15 years (Table 2-3).

Changes in the Industry

The commercial feed industry, which ranks among the top 25 industries in the U.S., currently is composed of an estimated 400 companies, with about 3,000 primary feed manufacturing plants serving another 10,000 secondary manufacturing plants. An estimated 70,000 persons are employed in primary feed manufacturing facilities and another 55,000 in secondary manufacturing plants. Approximately 20,000 dealers distribute feed products to producers, accounting for about 60% of retail feed sales. The remaining retail feed volume is sold directly to producers by feed organizations, including that sold directly to large producers who, in effect, become dealers themselves.

The changes mentioned above have brought new entrants into the feed supply business, as well as new product and service opportunities for existing feed manufacturing companies and dealers. Livestock and poultry producers in the U.S. are being offered an ever-widening array of low-inclusion products such as premixes and basemixes, as well as specific ingredients, to be mixed with their own grains and protein products. New and more refined on-farm mixing equipment is available, as well as nutrition consulting services.

Both traditional feed manufacturers and new suppliers to producers are becoming more attuned to working with larger, more

20 Ton/Hour General Purpose Feed Plant

Fred S. Stivers
The T.E. Stivers Organization, Inc.

This plant is designed for production of a general line of livestock feeds. Various options exist to tailor the plant to suit a particular location and regional market. The design provides for truck and rail receipt of ingredients, a batch mixing system, a pelleting system, grinding, crimping or dry rolling, a textured or molasses mixing system, and bagged and bulk handling for finished feed.

It is expected that most feed plants using this basic design would have grinding, batch mixing, and pelleting systems. Other systems and equipment could be tailored to suit particular needs. For example, the plant could be an all-bulk facility for manufacturing mainly swine and poultry pellets and mash feeds. In that case, the grain crimping, textured mixing, and sacking systems could be deleted. As another alternative, the plant could be designed for more textured dairy feed. For that approach, a steamer and cooler could be added to the grain crimping system to provide for steam rolled grains. The molasses feed mixing system could be modified for loading bulk textured feed direct to trucks.

Basic design criteria are established as follows:

	Tons Per Hour
Receiving	75
Grinding (1 mill @ 125 hp)	15
Mixing (2 ton mixer)	24
Crimping	5
Pelleting (1 mill @ 200 hp)	15-20
Overall Average Production	20

The plant is expected to generally operate one shift, 5 days per week. Production would be as follows:

Tons/Hour	20
Tons/Day	160
Tons/Week	800
Tons/Year	40,000

Receiving

It is assumed that approximately 90% of the ingredients will be received in bulk about equally split between truck and rail.

A handling rate of 75 tons per hour was selected. That will be about 3½ times the average production rate, which is more than adequate. However, that rate will provide for unloading 20- to 22-ton truck loads in about 20 minutes and 90-ton rail cars in about 1½ hours with some time allowance for moving vehicles.

It is assumed that only rail hopper cars will be handled. A single pit to accommodate one hopper car is provided. The car will need to be moved as each hopper is emptied. For this size of plant, it is not believed that a longitudinal conveyor, such that a rail car could be unloaded in one spot, could be justified.

A truck unloading grate, 10 feet wide by 6 feet long, provides for hopper bottom or self-dumping trucks. For this size operation, a truck dumper could not be justified. Also, some flexibility usually exists for specifying the type of trucks that can be received.

Incoming ingredient trucks will be weighed on the truck scale that is also used for outbound trucks.

Two feeder conveyors are provided for the truck and rail receiving pits. The conveyors discharge into a common gathering

chute above the receiving elevator inlet. At that point, a plate magnet is provided in the chute to remove ferrous material ahead of the elevator. The receiving elevator carries material to the top of the plant where it discharges either to a receiving scalper and to the overhead bins, or to the conveyor serving the outside storage. The scalper would normally have about a 1-inch mesh screen. All gravity flow would be used for distribution to the plant's bins. A conveyor is used for transfer to the outside storage area via a distributing turnhead.

As an option to this layout, the receiving scalper could be arranged to scalp ingredients going to both the plant and outside storage bins.

Grinding

Corn, milo, and alfalfa pellets are to be ground with a rate of about 15 tons per hour through a 1/4-inch screen. Actual usage of 60% ground materials will result in an average requirement of 12 tons per hour. A 125 hp, full-circle hammermill is selected. For even flow to the plant, a surge bin and feeder are located above the hammermill.

A by-pass valve is located ahead of the surge bin. This will permit the transfer of corn or milo to the working bins for cracking.

20 TON/HOUR GENERAL PURPOSE FEED PLANT Equipment Legend

- | | |
|--------------------------------------|------------------------------|
| 1. Rail Receiving Conveyor | 34. Scale Air Gate |
| 2. Truck Receiving Conveyor | 35. Scale Air Gate |
| 3. Magnet | 36. Batch Mixer |
| 4. Receiving Elevator | 37. Surge Bin |
| 5. Two-Way Valve | 38. Surge Conveyor |
| 6. Transfer Conveyor | 39. Mixing Elevator |
| 7. Turnhead Distributor | 40. Magnet |
| 8. Corn Storage Bin | 41. Mash Cleaner |
| 9. Milo Storage Bin | 42. Overs Regrinder |
| 10. Alfalfa Storage Bin | 43. Mash Distributor |
| 11. Receiving Scalper | 44. Mash Transfer Conveyor |
| 12. Receiving Distributor | 45. Mash Distributor |
| 13. Storage Bin Feeders | 46. Slide Gates |
| 14. Grain Transfer Conveyor | 47. Surge Bin |
| 15. Grain Transfer Elevator | 48. Pellet Mill |
| 16. Two-Way Valve | 49. Horizontal Cooler |
| 17. Surge Bin and Level Control | 50. By-Pass |
| 18. Hammermill Feeder | 51. Crumble Rolls |
| 19. Hammermill | 52. Cooler Air System |
| 20. Hammermill Discharge Conveyor | 53. Pellet Elevator |
| 21. Hammermill Air System | 54. Pellet Screener |
| 22. Grinding Elevator | 55. Two-Way Valves |
| 23. Grinding Distributor | 56. Pellet Distributor No. 1 |
| 24. Pneumatic Receiving Pipes | 57. Pellet Distributor No. 2 |
| 25. Grain Screener (with Aspiration) | 58. Air Slide Gates |
| 26. Two-Way Valve | 59. Collecting Hopper |
| 27. Grain Crimper | 60. Truck Scale |
| 28. Crimped Grain Elevator | 61. Bin Feeders |
| 29. Transfer Conveyor | 62. Molasses Mixer |
| 30. Two-Way Valve | 63. Surge Hopper |
| 31. Ingredient Bin Screw Feeders | 64. Feed Bagger |
| 32. Main Ingredient Scale | 65. Sewing Head |
| 33. Mineral Ingredient Scale | 66. Sewing Belt |

20 TON/HOUR GENERAL PURPOSE FEED PLANT

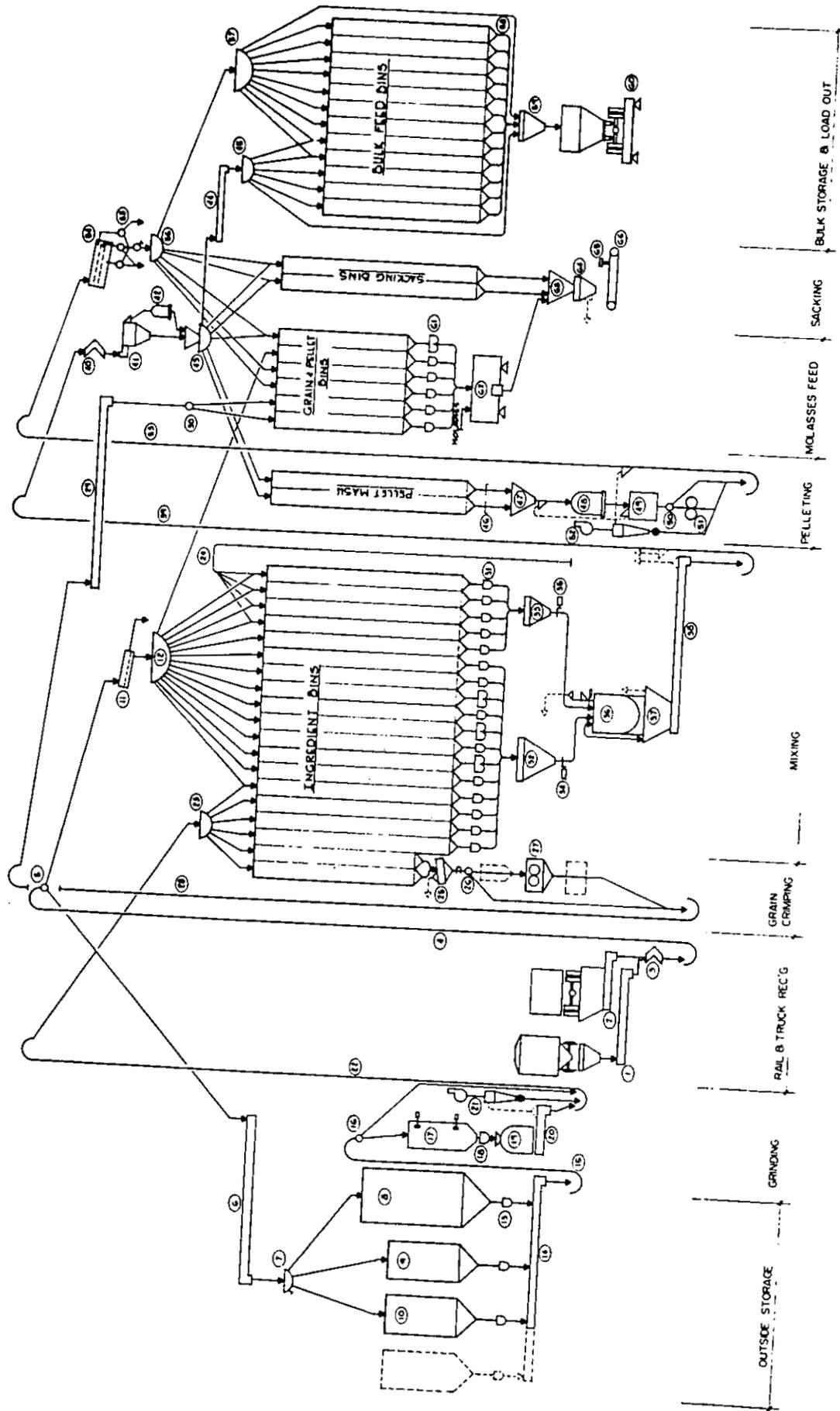


Fig. 5-4. Flow diagram.

20 TON/HOUR GENERAL PURPOSE FEED PLANT

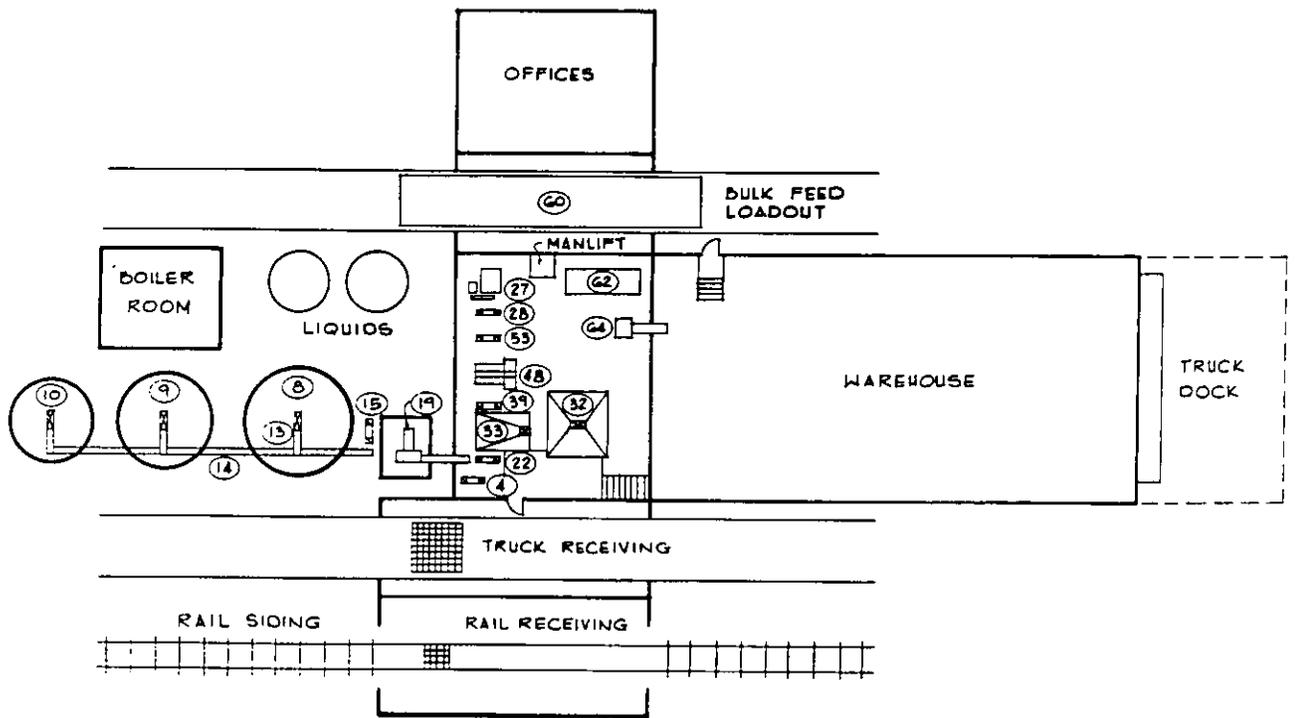


Fig. 5-5. Floor plan.

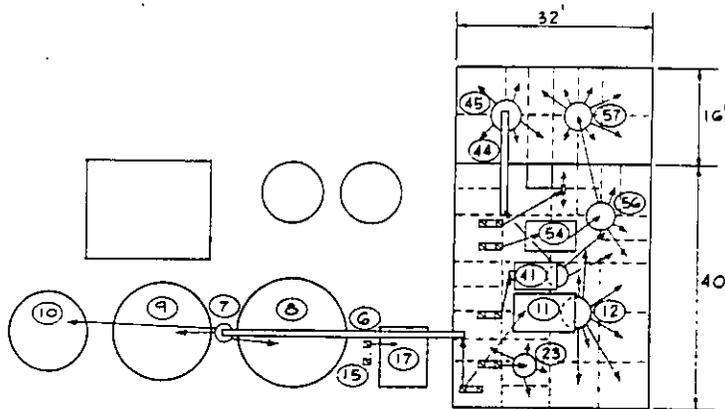


Fig. 5-6. Distribution plan.

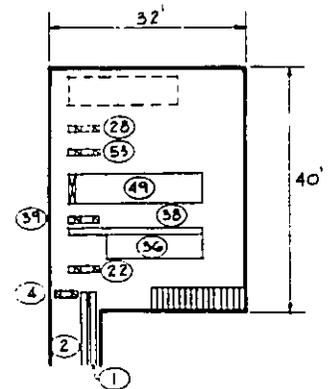


Fig. 5-7. Basement plan.

**20 TON/HOUR GENERAL PURPOSE FEED PLANT
INGREDIENT BIN ALLOCATION**

Ingredient	Outside Bins	Inside Bins
	Tons	Tons
Corn	500	—
Milo	150	—
Alfalfa Pellets	90	—
Corn		30
Oats		30
Ground Corn		30
Ground Milo or Corn		30
Ground Alfalfa		24
Ground Corn and Spare		30
Soybean Meal		120
Meat Meal		60
Cottonseed Meal		30
Wheat Midds		60
Bakery By-Product		30
Hominy Feed		60
Spare		30
Phosphate		30
Limestone		40
Urea		30
Salt		40
OTHER		
Pellet Mash		60
Molasses Feed Line		120
Sacking		60
Bulk Feed		200

Grain Crimping/Cracking

Two working bins are provided in the plant cluster. At the bin discharge, a single screen scalper is used to remove trash. A magnet is located below the scalper. The crimper/cracker is specified with a 25 hp motor for crimping and cracking grains.

A bucket elevator transfers processed material to 2 bins above the molasses feed system.

Mixing

The overhead ingredient bins have single and twin screw feeders to suit the particular ingredient. Twin screw feeders are specified for meat meal, wheat midds, and bakery by-product meal.

A 4000-lb and 1000-lb scale draw ingredients from the bins.

A two-scale, single mixer, computer controlled system is specified. It will store 25 formulas and control the weighing and mixing.

A floor dump provides for the introduction of hand-adds to the batch mixer.

A horizontal, 2-ton capacity, double ribbon mixer with drop bottom doors and a surge bin is provided. A paddle drag discharges the surge into a bucket elevator.

A rotary mash cleaner and double hump magnet conditions the finished mash. A small, 25 hp, 1800 rpm hammermill was specified to grind the feed cleaner overs; however, this is an optional item.

Finished mash feed flows by gravity to the pellet mash and the bagging bins. A transfer drag conveyor was chosen to serve the bulk truck loadout bins. The drag could be eliminated by raising the elevator about 25 feet.

Pelleting

Pelleting requirements call for 15 to 20 tons per hour of poultry, swine, and some cattle pellets. No high fiber items are expected to be pelleted.

Accordingly, a 200 hp pellet mill with conditioner equipped for molasses or pellet binder is specified. A 22-foot, horizontal cooler with 18,000 cfm of air will adequately cool the pellets. The cooling system will have twin, high efficiency cyclones set up as a negative system. Crumble rolls with a by-pass are located at the cooler discharge.

A double deck pellet screener was selected to scalp finished pellets and remove fines.

No fat coating system is included. However, provision is made for adding that in the future.

Molasses Feed

This plant is designed with the capability for making molasses feeds with crimped grains, pellets, and roughage. Due to the anticipated relatively low tonnage for these feeds, costs were minimized for this system. A horizontal paddle mixer, on scales, was selected. It will serve as the scales and mixer, including molasses addition.

The bins in this system will be hoppers about 12 feet higher than the regular mixing bins to keep the paddle mixer above the bagger. The molasses feed spouting is designed for gravity flow to the feed bagger.

Sacking, Storage, and Loadout

Two bins in the overhead cluster provide for sacked mash or pelleted feeds. The bagger also handles the molasses feed.

A 16 by 32 ft bin cluster is integral with the milling bins. Four large bins and eight split bins with 200 tons total capacity provide for bulk finished feed. They are located above the truck scale with the scale serving both ingredient and finished feed trucks.

50 Ton/Hour Full Line Feed Plant

W. Gary Winsett, PE
The T.E. Stivers Organization, Inc.

This plant design is based on an overall average production of 50 tons per hour. Operating on two shifts, the plant will produce around 200,000 tons of general line feeds annually. Specifically, the plant is geared for utilizing a relatively wide range of ingredients and by-products to produce mash, pellets, crumbles, steam rolled and dry cracked grains, scratch feeds, and textured ruminant feeds in both bagged and bulk forms.

The following projections are provided for the design criteria.

Type Of Feed	% of Total
Textured:	
Pellets	15
Grains	15
Other	5
	35
Meal and Mash	10
Beef and Dairy Pellets	25
Swine and Poultry Pellets	25
Scratch and Miscellaneous	5
	65
	100

From the above projections, the following is tabulated.

Type	%
Pelleted	65
Rolled	15
Non-Pelleted and Non-Rolled	20
	100

Bulk and bag receipts and shipments have been stipulated as follows:

Ingredient (%)		Finished Product (%)
Bulk		
Rail	60	10
Truck	36	50
	96	60
Bag		
Rail	2	5
Truck	2	35
	4	40
	100	100

Traffic Patterns and General Arrangement

Bulk and bagged ingredients via both rail and truck are to be handled. Outbound feed is to be shipped bulk and bagged via both truck and rail. The plant capacity requires two rail sidings and two truck driveways.

Based on the above data, one rail siding needs to be adjacent to the plant warehouse. Also, it is better to have rail sidings adjacent to each other. It is also desirable to avoid trucks having to cross the rail sidings. To suit the general requirements, the rail and truck is split with one on each side of the plant warehouse. The rail siding is

located on the "receiving" side and the truck driveways on the "shipping" side. That arrangement meets the basic criteria and provides workable and efficient traffic patterns.

Receiving

A 72-foot long by 360-ton capacity, AREA design railroad track scale provides for the weighing of incoming rail receipts. By switching, outbound bulk feed in rail cars and boxcars can also be weighed. The scale will have eight, 200,000-lb compression load cells and a 400,000-lb by 20-lb digital instrument. The 360-ton capacity and AREA design should meet most railroad requirements; however, that should be verified with the specific railroad servicing a particular plant. The scale has a concrete "floating" deck with a 40-foot grating section between the rails. A rail receiving conveyor also runs beneath the grating section. That allows for unloading hopper cars with one spotting.

Although it is being used less and less by most plants, boxcar unloading is provided. It utilizes a ramp and boxcar height dock with a small front end loader. For this particular design, the boxcar unloading is provided for handling such by-products as cottonseed hulls.

To provide flexibility in local ingredient purchases, a hydraulic truck dumper is specified. Due to relative costs and flexibility, the dumper is specified to be on load cells for weighing trucked ingredients. An alternative would be to use the truck scale on the load-out drive. The dumper/scale will be 70 ft long and have a 70-ton capacity to provide for foreseeable truck sizes at the location. Even larger scales may be required in some locations.

To accommodate the dumping of approximately 22-ton loads, a 1000-cubic foot receiving hopper is used.

The truck and rail scales are specified to have data transfer circuitry for automatically sending the net weight of a receipt, along with a manually entered product identification code, to the mill computer control system. That provides for the inventory system and a computer record of receipts.

Rail receiving has a transfer conveyor for carrying materials to the rail receiving elevator. For truck receiving, the same conveyor is used as a feeder and for transfer to the truck receiving elevator. Due to the by-products being handled, durability needs, and feeder requirements, screw type conveyors were selected for receiving.

Both trucks and rail receiving conveyors discharge into double sloped magnetic chutes just ahead of the elevator boot inlets. This utilizes a minimum of headroom and provides for the removal of ferrous metal ahead of the elevator legs.

The capacity of each of the truck and rail systems is set at 125 tons per hour on 40 lbs per cubic foot material. That is 2 1/4 times the average production rate. Also, it is preferable to receive only during the day shift. The elevators will have to be used for transfer of about 20% of the ingredients from outside storage to overhead mill working storage. To meet those requirements, the 125 tons per hour rate was selected. Provision could be made for having the two systems use the two elevators interchangeably. It would require more basement depth and would be relatively expensive.

Ingredient Distribution

The truck and rail receiving legs are located near the hub of the plant and outside storage bins. For this particular plant, ingredients must come to a central location and then be distributed. Accordingly, the centralizing is handled most efficiently by gathering on the lower level and then utilizing gravity flow on the topside.

Everything being equal, it is generally more desirable to maximize gravity flow over conveyed flow. However, as the horizontal configuration expands, a trade-off develops between elevator height and spouting runs versus conveying. For the design of this receiving/distribution system, the compromise selected uses all gravity flow to the plant and at the two outside storage clusters. Conveying is used for distribution to the two outside storage clusters. Also, all flow is positively controlled through single discharge conveyors and turnhead distributors. That is generally preferred over multiple discharge conveyors for plants handling nonfree-flowing ingredients.

To provide the required flexibility for receiving and transfer to the plant, dual spouted turnheads are specified. These have two inlet spouts and one set of outlet spouts. That provides transfer to any bin by either system or both systems to the same bin simultaneously. High level indicators provide an alarm and shut-down if a bin is overfilled.

This plant design, like most modern feed plants, requires provision for handling pneumatic discharge trucks (minerals) and

liquid hauling trucks. Ample parking is provided with the two truck driveways for those purposes. Pneumatic lines from ground level to the bin deck are provided.

Ingredient Bins

Table 5-1 shows the ingredients to be used along with the projected usage and storage provided. In the initial design considerations, the ingredients to be used and their daily usage were determined. The desired storage and the size of the receipt were also determined. The desired storage and receipt sizes were compared and the bin requirements determined accordingly; i.e., the bin(s) provide the minimum of desired storage of 1½ times the incoming load size.

An overhead bin cluster is generally the most desirable type of ingredient storage. It maximizes gravity flow into the mixing and other systems. On the other hand, outside ground level storage is less expensive. For a plant of this size and with the wide array of ingredients, a trade-off develops between these two approaches. A combination was chosen that utilizes both types of storage. A working bin for ingredients in outside storage is provided in the overhead cluster. Those ingredients can be transferred from outside to overhead storage through either the truck or rail receiving system. Also, bins for all major grains and products to be ground were located outside.

Table 5-1. INGREDIENT USAGE AND STORAGE OF 50 TON/HOUR FULL LINE PLANT.

Ingredient	Usage		Max. Load Size (Tons)	1½ × Load Size	Min. Days Storage Desired	Min. ⁽¹⁾ Storage Required Tons	Storage Provided		Outside ⁽²⁾ Storage Utilized
	% of Total	Tons Per Day					Tons	Days	
Corn	28	224	95	143	7	1568	1650	7	x
Milo	3	24	90	135	10	240	280	12	x
Barley	3.2	25.6	75	113	10	256	250	10	x
Oats	4	32	40	60	7	224	200	6	x
Wheat	2	16	90	135	5	135	160	16	x
Corn Screenings	6.2	49.6	75	113	7	350	450	9	x
Dust Pellets	2	16	75	113	4	113	125	8	x
Brewers Grains	2	16	60	90	5	90	120	8	x
Malt Hulls	2	16	40	60	4	64	70	4	x
Alfalfa Pellets	1.5	12	70	105	5	105	180	15	x
Wheat Midds	12	96	45	68	5	480	450	5	x
Bakery By-Product	4	32	22	33	3	96	120	4	
Cottonseed Hulls	3	24	40	60	5	120	100	4	
Beet Pulp	0.5	4	60	22	7	33	40	10	
Soybean Meal — 48	11	88	90	135	7	616	610	7	x
Soybean Meal — 44	3	24	80	120	5	120	120	5	
Cottonseed Meal	3	24	75	113	5	120	120	5	
Meat Meal	2	16	22	33	4	64	75	5	
Corn Gluten Meal	2	16	80	120	10	160	125	8	x
Limestone	0.4	3.2	22	33	5	33	40	13	
Phosphate	0.8	6.4	90	135	5	135	140	22	
Salt	0.1	0.8	22	33	5	33	35	44	
Urea	0.3	2.4	22	33	5	33	30	13	
Sub-Total	96.0	768	—	—	—	—	5490	7 avg.	
Liquids	3.6	28.8	22	33	5	144	150	5	
Micros & Hand-Adds	0.4	3.2	—	—	—	—	—	—	
Total	100.0	800.0	—	—	—	—	5640	7 avg.	

(1) Dictated by either 1½ × load size or min. days storage desired, whichever is greater.

(2) Outside storage utilized, either because of cheaper storage or because material is to be ground.

50 TON/HOUR GENERAL PURPOSE FEED PLANT

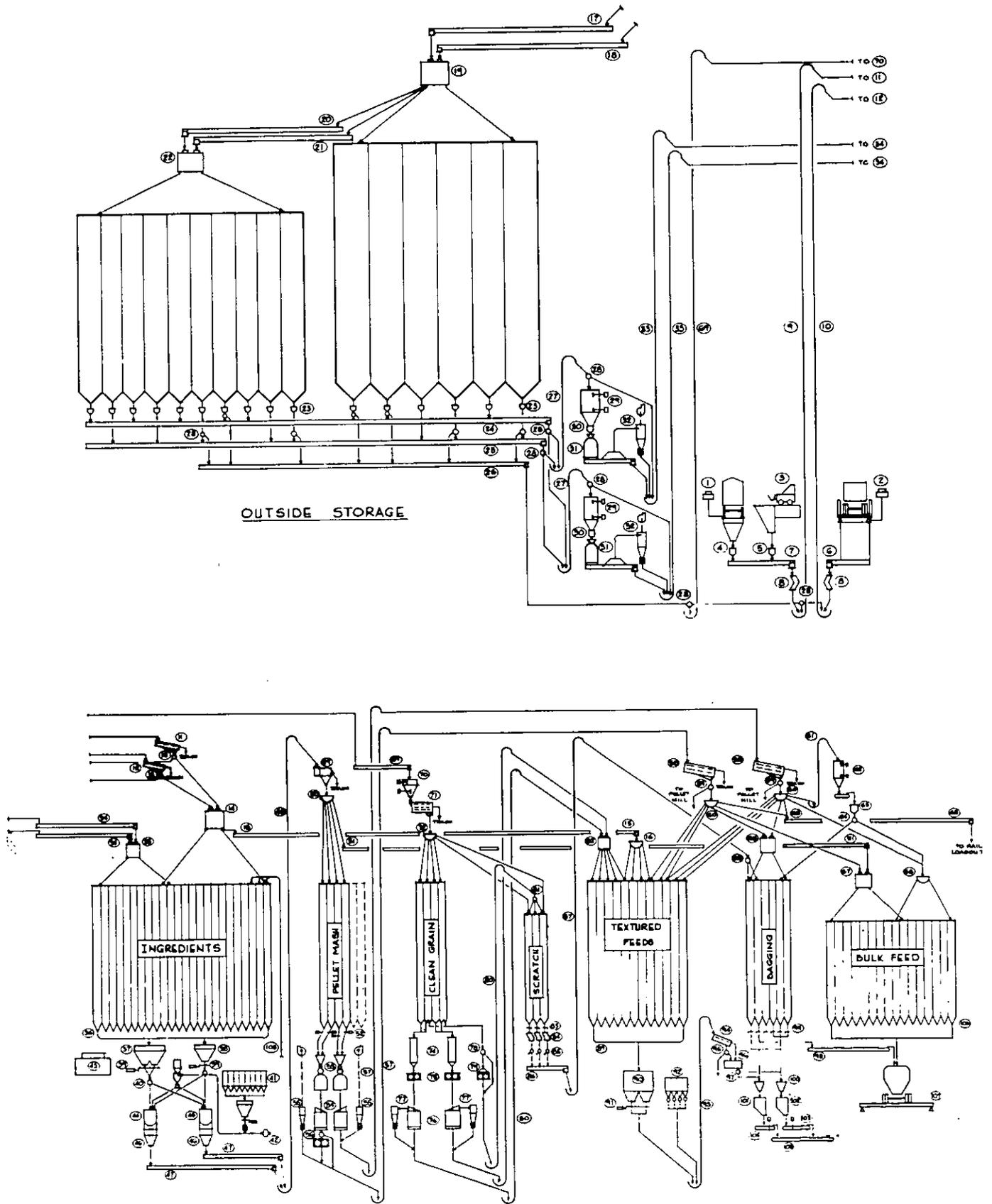


Fig. 5-8. Flow diagrams.

50 TON/HOUR GENERAL PURPOSE FEED PLANT
Equipment Legend

1. Rail Scale
2. Truck Dumper and Scale
3. Front End Unloader
4. Rail Receiving Feeder
5. Box Car Receiving Feeder
6. Truck Receiving Feeder
7. Rail Transfer Conveyor
8. Receiving Magnets
9. Rail Receiving Elevator
10. Truck Receiving Elevator
11. Rail Receiving Scalper
12. Truck Receiving Scalper
13. Two-Way Valves
14. Mill Receiving Distributor No. 1 (Dual Spout)
15. Transfer Conveyor
16. Mill Receiving Distributor No. 2
17. Rail Distribution Conveyor No. 1
18. Truck Distribution Conveyor No. 1
19. Outside Storage Distributor No. 1 (Dual Spout)
20. Rail Distribution Conveyor No. 2
21. Truck Distribution Conveyor No. 2
22. Outside Storage Distributor No. 2 (Dual Spout)
23. Outside Storage Bin Feeders
24. Grinding Transfer Conveyor No. 1
25. Grinding Transfer Conveyor No. 2
26. Grain & Ingredient Transfer Conveyor
27. Grinding Transfer Elevators
28. Two-Way Valves
29. Level Indicators
30. Hammermill Feeders
31. Hammermills
32. Hammermills' Air Assist System
33. Grinding Elevators
34. Grinding Distribution Conveyors
35. Grinding Distributor (Dual Spout)
36. Ingredient Bin Feeders
37. Major Batching Scale — 5 Tons
38. Minor Batching Scale — 1 Ton
39. Air Slide Gates
40. Two-Way Valves
41. Microingredient System
42. Microingredient Transfer System
43. Computer Based Control System
44. Batch Mixer — 5 Tons
45. Mineral Mixer — 3 Tons
46. Surge Hoppers
47. Surge Discharge Conveyors
48. Mash Elevator
49. Rotary Feed Cleaner
50. Mash Distributor
51. Mash Loadout Conveyor
52. Air Slide Gates
53. Pellet Mills
54. Horizontal Pellet Coolers
55. Cooler Air Systems
56. Crumbler Rolls
57. Pellet Elevators
58. Pellet Screeners
59. Screener Two-Way Valves
60. Pellet Distributors No. 1 and No. 2
61. Fat Coater Elevator
62. Fat Coater Surge and Level Controls
63. Fat Coater Feeder and Blender
64. Two-Way Valve
65. Rail Loadout Conveyor
66. Pellet Distributor No. 3 (Dual Spout)
67. Bulk Feed Distributor No. 1 (Dual Spout)
68. Bulk Feed Distributor No. 2
69. Grain Transfer Elevator and Conveyor
70. Surge Hopper and Level Indicators
71. Grain Cleaner (3 decks)
72. Clean Grain Distributor
73. Slide Gates
74. Grain Chest Steamers
75. Roller Mills
76. Horizontal Rolled Grain Coolers
77. Cooler Air Systems
78. Two-Way Valve
79. Dry Grain Roller Mill
80. Cracked and Rolled Grain Elevators
81. Three-Way Valve
82. Rolled Grain Distributor (Dual Spout)
83. Slide Gates
84. Volumetric Scratch Feeders
85. Test Valves
86. Blending Conveyor
87. Scratch Grain Elevator
88. Two-Way Valve
89. Textured Bin Feeders
90. Textured Batch Scale — 3 Tons
91. Double Slide Air Gate
92. Microsystem
93. Textured Elevator
94. Screener (2 Screens)
95. Two-Way Valve
96. Molasses Mixer
97. Two-Way Valve
98. Belt Conveyor
99. Air Slide Gates
100. Surge Hoppers
101. Molasses Feed Bagger
102. Pellets/Mash Feed Bagger
103. Sewing Heads
104. Sewing Belts
105. Bag Belt System
106. Air Slide Gates
107. Truck Scale
108. Pneumatic Receiving (Pipes and Filter)
109. Freight Elevator

Equipment Not Shown

- High and Low Level Indicators
- Liquid Handling Systems
- Dust Control Equipment
- Boiler and Steam Equipment

50 TON/HOUR GENERAL PURPOSE FEED PLANT

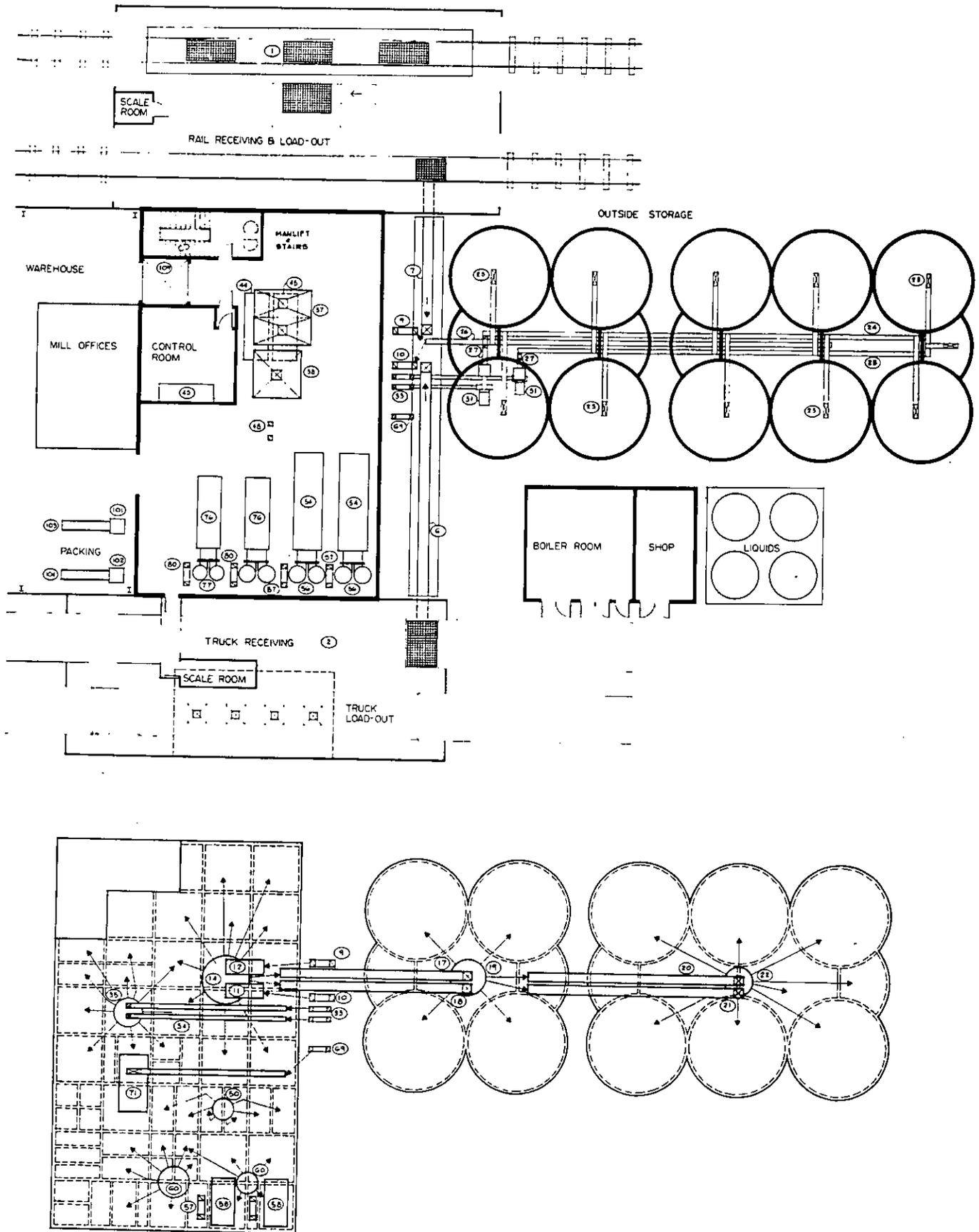


Fig. 5-9. Mill and outside storage, top view.

50 TON/HOUR GENERAL PURPOSE FEED PLANT

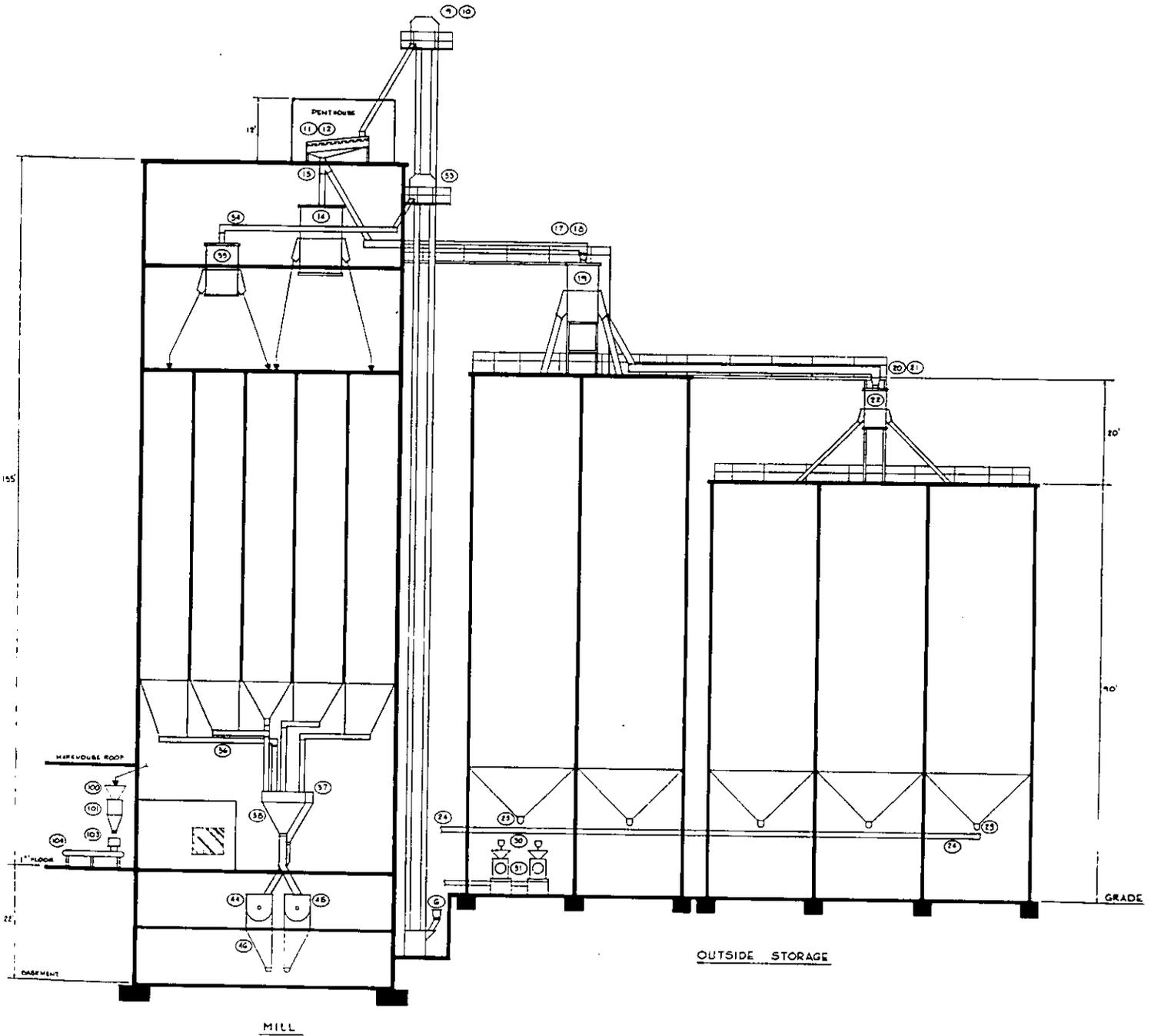


Fig. 5-10. Mill and outside storage, side view.

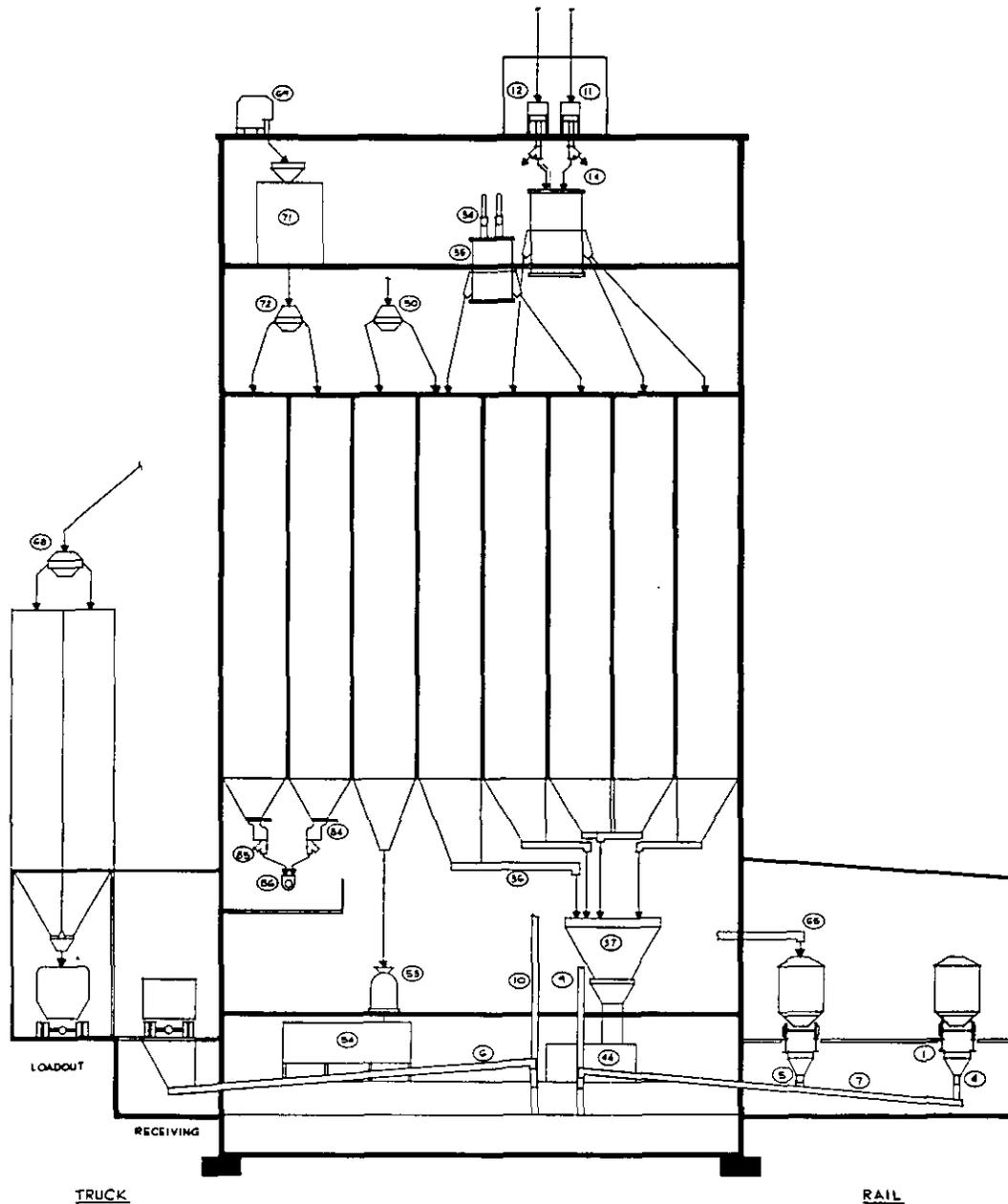


Fig. 5-11. Receiving and loadout.

Grinding

From the ingredient usage data, the ingredients to be ground amount to about 22 tons per hour. Some ingredients to be ground are by-products and relatively fibrous in nature. Also, all materials are to be fine ground for pelleting and coarse ground for mash feeds.

Based on those requirements, two independent grinding systems are specified. The hammermills will be full circle, top feed with air-assist systems. 125 hp, 1800 rpm motors are specified. Rotor diameter will provide about 21,000 feet per minute peripheral speed with the 1800 rpm motors. That will minimize vibration, noise, and maintenance and provide satisfactory grinding action. The air-assist systems with about 1500 cfm each will

improve capacity, particularly with the lower density by-products, and help control dust emissions.

Bin discharge feeders with manually adjustable, variable pitch sheave drives are provided. A transfer conveyor conveys material to a short height bucket elevator. The elevator discharges into a surge hopper with high and low level indicators. Beneath the surge, a variable speed pocket feeder feeds the hammermill. The feeder speed will be remotely controlled to suit either hammermill motor load or through-put capacity, whichever controls. The surge hopper and level indicator system will keep material ahead of the feeder. The manually adjustable bin feeders can be varied periodically to suit conditions.

In light of energy requirements and costs and for reducing shrink losses, a mechanical handling system with conveyor and bucket elevator was selected for transfer to the overhead working bins in the plant. For this particular design, a conveyor is used across the top of the bin deck. An option would be to increase the height of the grinding elevator and utilize gravity flow to eliminate the conveyor. Again, as in the case of receiving, a dual spouted turnhead distributor is specified to meet flexibility requirements.

This plant layout has the hammermills in the skirted area below one of the outside storage bins. Another approach would be to locate the hammermills in the basement. The rationale for the design provided was to isolate the hammermills to reduce noise levels in the working areas of the plant, to reduce the hazards of fire and explosion, and to provide easy accessibility to the equipment.

Grain Cleaning and Processing

As noted in the ingredient bins selection, grains are stored outside. A transfer system carries grain to the top of the plant for cleaning. That allows cleaning to be done on a 20-ton per hour rate, as needed. That is more economical than cleaning grain as it is received. Gravity flow is utilized from the grain cleaner to the clean grain bins to eliminate cross contamination and provide good clean grains.

The plant design calls for up to 5 tons per hour of steam rolled corn with a density of 25 lb per cubic foot, plus 5 tons per hour on at least two other grains. These requirements dictate two roller mills. Also, for flexibility, two completely independent systems are selected. Vertical, stainless steel chest steamers with 30 min of retention time will condition the grain. 75 hp, 18 by 36 in., hydraulic tensioned roller mills were selected.

Horizontal coolers were specified and are located in the basement. Negative cooling systems pull up to 14,000 cfm of air from each of the coolers. The rolls are on the first floor. Bucket elevators and gravity flow provide for distribution of the rolled grains to the textured system working bins. The gravity flow is simple, minimizes conveying, and reduces product damage. A section of the gravity flow spout between the bins and steamer should be open on top or vented to the cooler system to prevent excess steam from wetting the grain in the overhead bins.

Beside the roller mills, a dry roller mill provides for cracked grain. It has a separate elevator for distribution to three scratch grain bins. System capacity is 5 tons per hour. The rolls have a bypass valve, so this system can also be used to transfer cleaned grain to the scratch bins for blending or to go on to bagging.

Batch Proportioning

Due to the relatively large number of bins, two batching scales were chosen. The main scale will have a 5-ton capacity, and the second scale will have a 1-ton capacity. That will enable the 1-ton scale to more accurately weigh minor ingredients, such as minerals. The number and capacity of scales should be selected depending upon the number of ingredients (bins) and the accuracy with which each ingredient must be proportioned. The lower the scale capacity, the greater the resolution and the increment by which it can weigh.

The larger scale has a double 18- by 24-inch gate discharge for quick discharge time and to eliminate bridging.

Screw feeders are used on the overhead ingredient bins to batch materials to either one of the two hopper scales. The feeders are various sizes, consist of single, twin, and triple screw arrangements, and are designed to handle a particular ingredient. That provides better flow, minimizes bridging, and provides optimum

feed rates for better scale accuracy and reduced batching times. Sizes, speeds, pitch of flighting, inlet size, and horsepower are designed to batch the various formulas within a 3-minute draw time. Also, on small items or draws, the time is selected so the bin feeder will be running for a minimum of about 5 seconds. That is for scale reaction time and accuracy.

A consideration for this plant that is being used more and more was the specification of an automatic microingredient system. A cluster of 14 bins with approximately 400 lbs capacity each is included. Two-speed screw feeders with 2-inch and 3-inch helixes provide the rates and accuracy needed. A 75-lb net capacity by 0.05-lb graduation electronic scale is used. That will provide for handling about 90% by volume of the microingredients. The remaining 10% consists of over 15 items. Those will be added by hand. The savings in this case was one man plus better accuracy and control.

An automatic computer based batching control system is justified in a feed plant of this size. The control system will have computer memory for up to 150 formulas. Formula files will be updated by operator keyboard entry on a weekly basis. The operator then enters the formula number and the number of batches to be made. Ingredients will be fed to the scales in sequence in the required amounts.

Automatic freefall or midair compensation will be provided by the computer system along with scales discharge, mixing, and mixer discharge. As a future option, automatic routing by the computer can also be added to the system. The control system also includes an inventory system for keeping track of ingredients, as well as for generating production records.

Mixing

A single 5-ton capacity horizontal ribbon blender with drop bottom was selected. It will provide satisfactory mixing and meet capacity requirements. The drop bottom will provide complete cleanout. Also, a second nominal 3-ton horizontal ribbon mixer was specified for mineral and special mixes. It can also serve as a back-up to the main mixer. Surge hoppers are provided under the mixers to reduce discharge time.

The batch mixing system will operate on a 5-minute cycle. That will provide about 1/2 minute for complete scale discharges to the mixer, 3 1/2 minutes for mixing, 1/4 minute for discharge, and 1/4 minute contingency. With the maximum 5-minute total, there will be 12 batches per hour. At 5 tons per batch, system capacity is 60 tons per hour. With reasonable efficiency on formula changes and hand adds, net capacity should be 50 tons per hour or better.

Mechanical conveying and elevating is used to transfer finished mash feeds to the bin deck for distribution to the various bins for further processing or as finished feed for loadout. Mechanical conveying was chosen over pneumatic because of noise, power, and cost considerations. The surge discharge conveyors will have two-speed motors. The slower speed will provide for heavy or light density mixes.

A rotary feed cleaner is used at the mash elevator discharge to dress the mixed feed. An option at this point would be to provide an onstream regrinder for grinding overs from the feed cleaner and putting them back into the feed.

Pelleting

From the basic requirements, total pelleting is to be about 65% of the total tonnage. At a 50-ton per hour overall rate, the pelleting rate would be 33 tons per hour. That will range from poultry pellets that will require about 10 hp per ton-hour to dairy

pellets at about 20 hp per ton-hour. To handle these requirements, two 300 hp pellet mills are specified. Special conditioners and piping harnesses are also included to add molasses and one other liquid, along with steam, at the conditioner. Automatic micro-processor based pellet mill controls are specified.

Double-pass horizontal coolers fit with the pellet mill discharge and elevator locations. Crumble rolls are provided on one system for making poultry and turkey feed crumbles. Close coupled, twin unit, high efficiency centrifugal cyclones are used. They are located adjacent to the coolers to minimize the duct length between the cooler and cyclones. The ducting and the cyclones are specified as 14-gauge stainless steel. Since most condensation and choke problems occur ahead of the cyclones, this layout minimizes the length. Also, since the pellets are to be screened on top of the plant, there is no significant advantage to locating the cyclones high in the plant for discharge back to the pellet mill; therefore, the discharge of the cyclones is directed into the cooled pellet stream.

The cooler fans will be located either on the truck shed roof or on one of the upper plant decks for better dispersion of the moist air.

Another design feature provides an additional 2500 cfm of air on the fan and cyclones. That will be for aspirating the pellet elevator and the pellet mill feeder-conditioner for dust control.

Each pelleting system has a screener on top at the elevator discharge to scalp and remove fines. The system with the crumbler will be a three-deck screener to permit grading of crumbles. Remote controlled valves are specified at the screener discharges to give the flexibility of returning fines to the pellet mill or to the bin, and overs to trash or to the bin.

Fat Coating

A fat coater system with elevator, surge, feeder, blending screw, and pump is provided for coating pellets and crumbles. It is located on the plant's upper deck.

Scratch

A small continuous-mixing scratch grain system is provided. It includes volumetric feeders for metering material from overhead bins into a mixing conveyor. An elevator transfers scratch feeds to either of two bagging bins for packaging.

Although overall requirements are for about 3 tons per hour, the system is rated at 20 tons per hour so that it will not tie up the bagging bins and can keep up with packaging when a run is to be made. The system can accommodate cracked grains from the dry roller mill and cleaned whole grains from the grain cleaner.

Textured Feed

A complement of 12 bins is designed to hold ingredients for the textured, molasses feed line. The bins provide for rolled grains, pellets, roughage ingredients from the receiving system, and mash. The spouting is overlapped for flexibility in bin usage. Capacity for this system is specified at 30 tons per hour to be consistent with overall production requirements of about 30% of the total.

For proportioning ingredients, a batch system was selected. While the cost is slightly more than for continuous volumetric proportioning, accuracy will be improved, and starting and stopping problems are eliminated. Also, the batch system can be controlled by the computer based control system and tie-in with inventory and production record systems much better. The scale will have a capacity of 3 tons. A small microcluster with volumetric feeders for minerals and small items is provided. It will be auto-

matically controlled with the main scale.

Drawn ingredients are elevated to about 30 feet above the first floor with a slow speed elevator that discharges across a scalper for removing lumps. Next, a slow speed paddle mixer runs for about a minute to blend ingredients and add molasses. Mixed feed, then, flows by gravity into a specially designed surge bin above the molasses feed bagger or onto a belt for loading bulk trucks.

For bagged feed, the layout provides gravity flow after molasses is added to avoid conveyors and material build-up problems. Spouts and chutes should be kept steeper and larger than normal and access doors should be provided to clean out the spouts. Depending on the amount of molasses, the belt loading to trucks will require frequent cleaning. An option, depending on usage, would be to blend the molasses at the truck loading point. A floor drain, curb, and hot water are provided for washing the mixer, spouts, and molasses feed bagger.

Bagging

Initially, 40% of the finished feed is to be bagged. That is projected to decrease to 30% in 5 years. Also, molasses, and pelleted and mash feeds are to be bagged. To handle these requirements, a net weighing, automatic bagger is provided for handling mash, pellets, and some specialty formulas. Many companies find that good equipment will achieve up to 14 bags per minute with an accuracy of ± 2 oz (2 standard deviations). Also, a special molasses bagger with cleanout provisions is provided for high molasses feeds. Automatic sewing machines and sewing belts are provided for the baggers. The baggers have solid state microprocessor controls for accuracy and speed.

Bulk Finished Feed Bins

Sixteen finished feed bins of 30 tons capacity each, or a total of 480 tons of storage, are provided initially. This is expandable. The bulk loadout bins are located over the truck loadout driveway, separate from the main plant, and are filled via gravity flow. A truck scale under the bins provides for weighing the outbound trucks.

Warehousing

With the finished product being 40% bagged (decreasing to 30% by the fifth year), plus 4% of the incoming ingredients received in bags, a relatively large warehouse is required. No size projections or details were determined for this design. However, it is anticipated that bag conveying belts would be used for palletizing and forklifts used for handling pallets — either standard pallets or minipallets.

Ancillary Facilities

From the fire hazard and housekeeping standpoints, a separate building is provided for the boiler room and shop. Employee facilities and plant offices will be located at the end of the warehouse adjacent to the plant.

Building and Bins Construction

For the outside storage clusters, steel and slipformed concrete were considered. Overall, concrete was found to be most economical. That resulted mainly from the fact that concrete bins can be clustered to utilize common walls and provide interstice bins. That also reduced equipment and spouting costs. Another factor is that, while steel is relatively cheap for free flowing grains,

it becomes considerably more costly if it is designed for materials that normally bridge, such as soybean meal.

For the plant building, steel would be cheaper. However, consistent with the outside storage construction, durability, maintenance, expected life, and appearance, slipform concrete was chosen.

The design layout includes a plant basement with a dock high first floor as the main work floor. At the same time, the plant could

be built without a basement except for receiving pits. Depending on subsurface conditions, it could be cheaper. The main disadvantage is that the work floor is on a third level, about 30 feet above grade. However, with remotely controlled equipment, microsystem, freight elevator, and a manlift, that becomes less of a factor. In general, the two approaches should be compared for a specific plant in light of subsurface conditions, hand-add ingredients, crewing, and related operating parameters.

50 Ton/Hour Batch Poultry Feed Plant

D. A. McEachin, PE
The T.E. Stivers Organization, Inc.

This is a batch type poultry specialty plant designed for high volume production of a limited number of poultry feed formulas, all in bulk form. The plant is designed for net production of 50 tons per hour, two 8-hour shifts per day. This equates as follows:

Ton Per Hour	50
Hours Per Day	16
Tons Per Day	800
Tons Per Week	4,000
Tons Per Year	208,000

Future growth is uncertain. However, provision is made for adding a second mixer. It is believed that this provision, together with the basic plant design, would allow production to increase to about 75 tons per hour of mixed feed. No special provision is made for increased pelleting capacity. However, with the advent of larger pelleting machines, it is expected that one, or both, of the initial 250 hp machines could be replaced with larger 300 or 350 hp machines.

Another alternative for increased production that should be considered would be the possibility of adding a third shift. For a modern plant of this nature, a third shift can normally be handled by two people.

The plant construction would most likely be slipform concrete for the basic tower and outside storage cluster. The plant design assumes production of mash, pelleted, and crumbled poultry feeds using a 4-ton mixing system with surge bin. Since the plant is making a limited number of poultry feed formulas using an automatic control system, it can easily handle the 800 tons per day requirement on two 8-hour shifts.

The site plan must take into account many factors including size and shape of the property; access by road and rail; contour of the land; plant, storage, and warehouse requirements (now and in the future); parking for trucks and autos; office space; truck maintenance; and other activities that may occur at the site.

To meet all of those requirements, adequate space must be provided. An 8-acre plot with 800 feet of rail siding is considered as a minimum. A better standard is to have at least 10 acres with 1000 feet of siding. The property usually exists near the edge of a town where fire and police protection are available, rail switching is convenient, and personnel and other business activities are not far removed.

There are a great many choices in plant layout. Some of the ideas shown here are compromises where a case could be made for a stronger design in one area, offset by a weaker design in another area.

The liquid storage calls for three 8000-gal. tanks; however, tank sizes and number should be based on the number of liquids handled. Tank capacity should be at least 1½ times the maximum delivery of each liquid. Generally, it is a good idea to provide a

minimum of two fat tanks so that a new load can be tested before use. Cone bottom fat tanks can be used to prevent an accumulation of sludge.

Liquids are normally stored in steel tanks above ground or can be in underground steel or concrete tanks located under the warehouse adjacent to the plant. Location will affect the pumping arrangement and amount of heat required for storage and pumping, especially for fat. Work tanks can be located in the plant close to the point of application. In many cases, it is more economical to forego work tanks and pump directly from the storage tanks.

It can be noted on the layout drawings that the location of outside storage bins may appear to be too far from the plant building. In this example, extra space was allowed for future bin expansion. In the final analysis, they would probably be moved closer to the plant building.

This layout assumes that the office, laboratory, boiler room, and shop are located at least 30 feet from the plant. Location of available rail siding is a key factor in the property layout. In this case, there is no need for rail receipt of bagged ingredients, and the siding does not have to be placed alongside the warehouse.

Electric power and service facilities entering the plant can usually be made to conform to a reasonable layout, and they have not been considered further in this planning; although they are vital factors to the design engineer.

Explanation of Drawings

Receiving. All ingredients are received in bulk quantities except for the microingredients that amount to less than 1% of the total. Microingredients are received and stored in bags and emptied into the bulk microhoppers as required. Up to 4 percent of the ingredients are liquid and are received by truck.

The easiest bulk materials to receive are liquids and materials that come in hopper cars. A rail receiving system has been provided, complete with a rail scale. After rail cars have been weighed, they are emptied through a series of conveyors, an elevator, and a scalper to the distribution systems over the bins. Rail scales have generally been found profitable in large plants of this type, both for checking shippers' weights and for input to computerized inventory systems.

Bulk ingredients in trucks are unloaded by a truck dumper with a scale into a hopper where a conveyor takes them to a bucket elevator. Those ingredients are then distributed to the various bins.

Valving is provided between the rail and truck systems so that either the receiving conveyor or bucket elevator can be used for receiving ingredients from both modes of transportation.

50 TON/HOUR INTEGRATED FEED PLANT
Equipment Legend

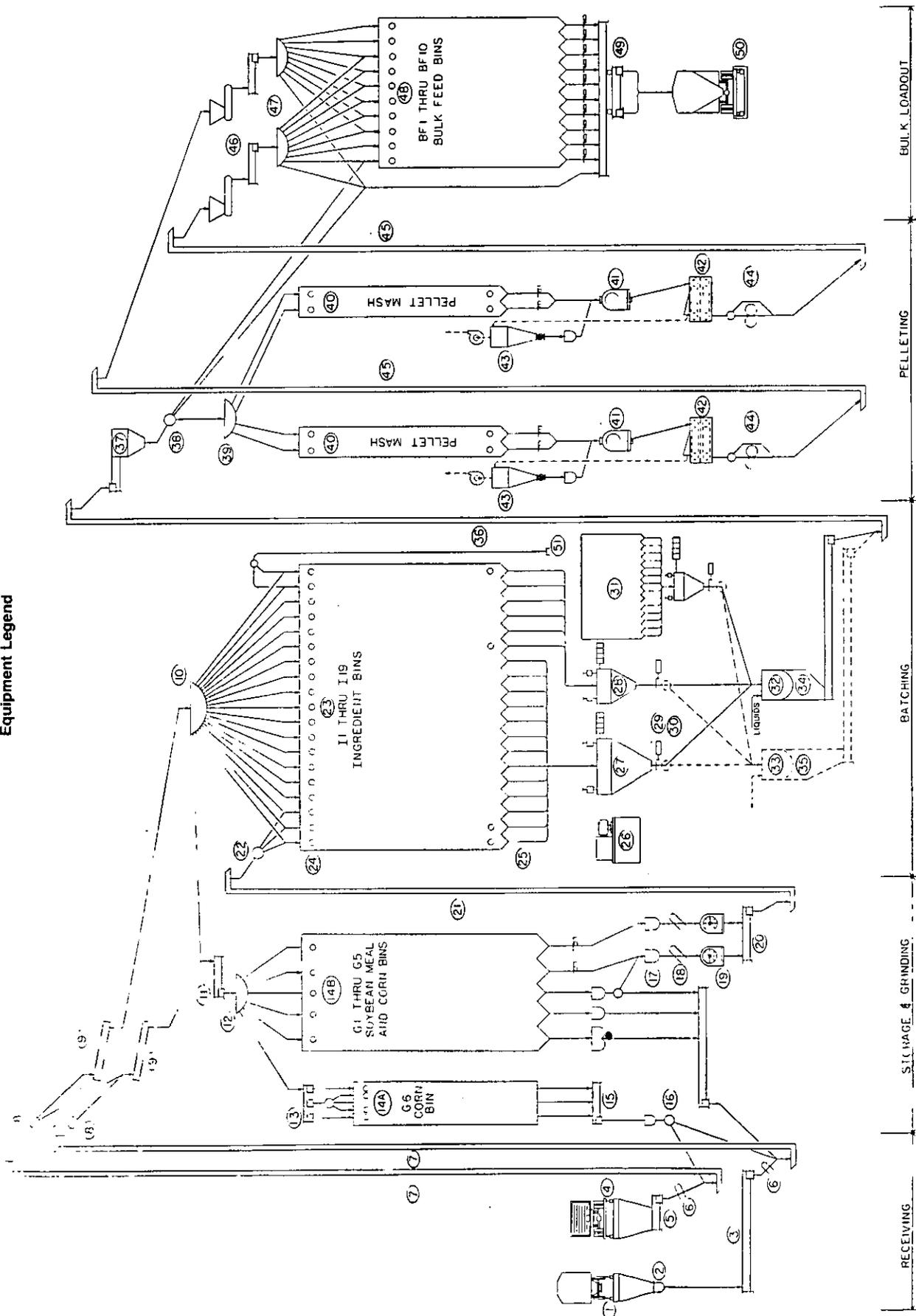
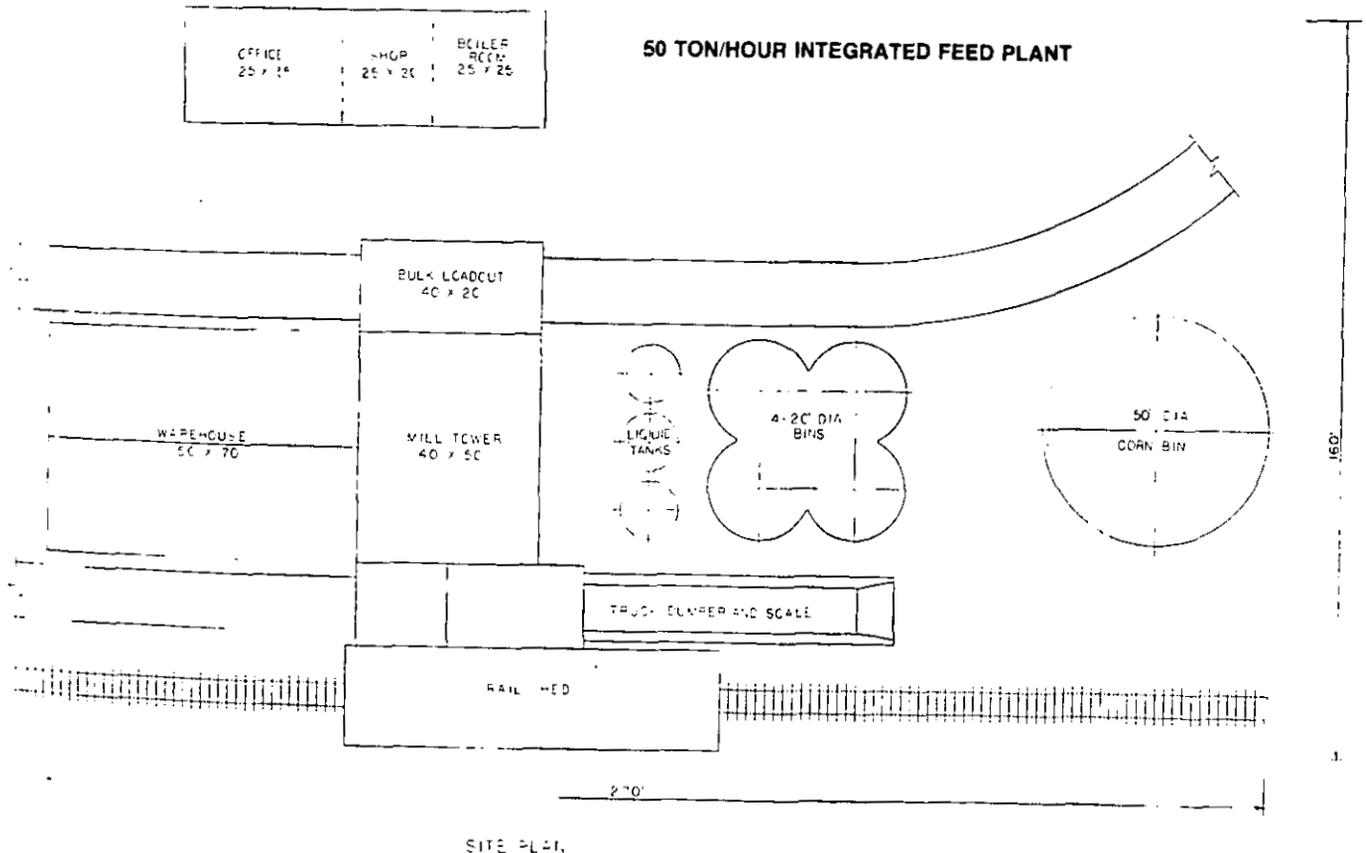


Fig. 5-12. Flow diagram.

50 TON/HOUR INTEGRATED FEED PLANT
Equipment Legend

- | | |
|---|--|
| <ol style="list-style-type: none"> 1. Rail Scale 2. Rail Receiving Feeder Screw 3. Rail Transfer Conveyor 4. Truck Dumper and Scale 5. Truck Receiving Feeder Screw 6. Receiving Chute Magnets 7. Receiving and Transfer Elevators — 150 T.P.H. 8. Two Way Valves 9. Receiving Scalpers 10. Receiving Distributor No. 1 11. Transfer Conveyor 12. Receiving Distributor No. 2 13. Corn Bin Distribution/Spreader Conveyor 14A. Corn Bin — 150,000 Bushel or 4200 Tons 14B. Outside Ingredient Corn Bins — 71,500 Bushels or 2000 Tons 15. Bin Feeder Screws and Transfer Conveyors 16. Two-Way Valve 17. Hammermill Feeders 18. Hammermill Magnets 19. Hammermills — 125 hp 20. Hammermills' Discharge Conveyor 21. Grinding Elevator — 50 TPH 22. Three-Way Valve 23. Ingredient Bins 24. Level Indicators 25. Ingredient Screw Feeders 26. Computer Based Control System 27. Batch Scale No. 1 — 8,000 lbs 28. Batch Scale No. 2 — 2,000 lbs 29. Scales' Discharge Gates 30. Future Two-Way Valves | <ol style="list-style-type: none"> 31. Micro Ingredient System — Bins, Feeders and Scale 32. Mixer No. 1 — Horizontal Ribbon Blender 33. Future Mixer No. 2 34. Surge Bin and Discharge Conveyor 35. Future Surge Bin and Discharge Conveyor 36. Mash Elevator — 80 TPH 37. Mash Cleaner — Rotary 38. Three-Way Valve 39. Mash Distributor 40. Pellet Mash Bins 41. Pellet Mills — 250 hp 42. Pellet Coolers — Horizontal 43. Pellet Cooling Air Systems (Cyclones, Fans, Airlocks, Conveyors, Ducts) 44. Crumble Rolls 45. Pellet Elevators — 40 TPH 46. Fat Coaters 47. Pellet Distributors 48. Bulk Finished Feed Bins 49. Bulk Feed Shuttle Conveyor System 50. Truck Scale — 10 ft x 80 ft x 80 Ton 51. Pneumatic Receiving (Pipe, Filter, Valves) |
|---|--|

Other Equipment Not Illustrated:
 Liquid Storage Tanks (Fat, Choline, Methionine)
 Liquid Handling Systems (Pumps, Meters, Valves)
 Receiving Dust Control System (Filter, Fan, Ducts)
 Grinding Dust Control (Filter, Fan, Ducts)
 Mixing Dust Control System (Filter, Fan, Ducts)
 Boiler
 Compressed Air System



270'

SITE PLAN.

Fig. 5-13. Site plan.

50 TON/HOUR INTEGRATED FEED PLANT

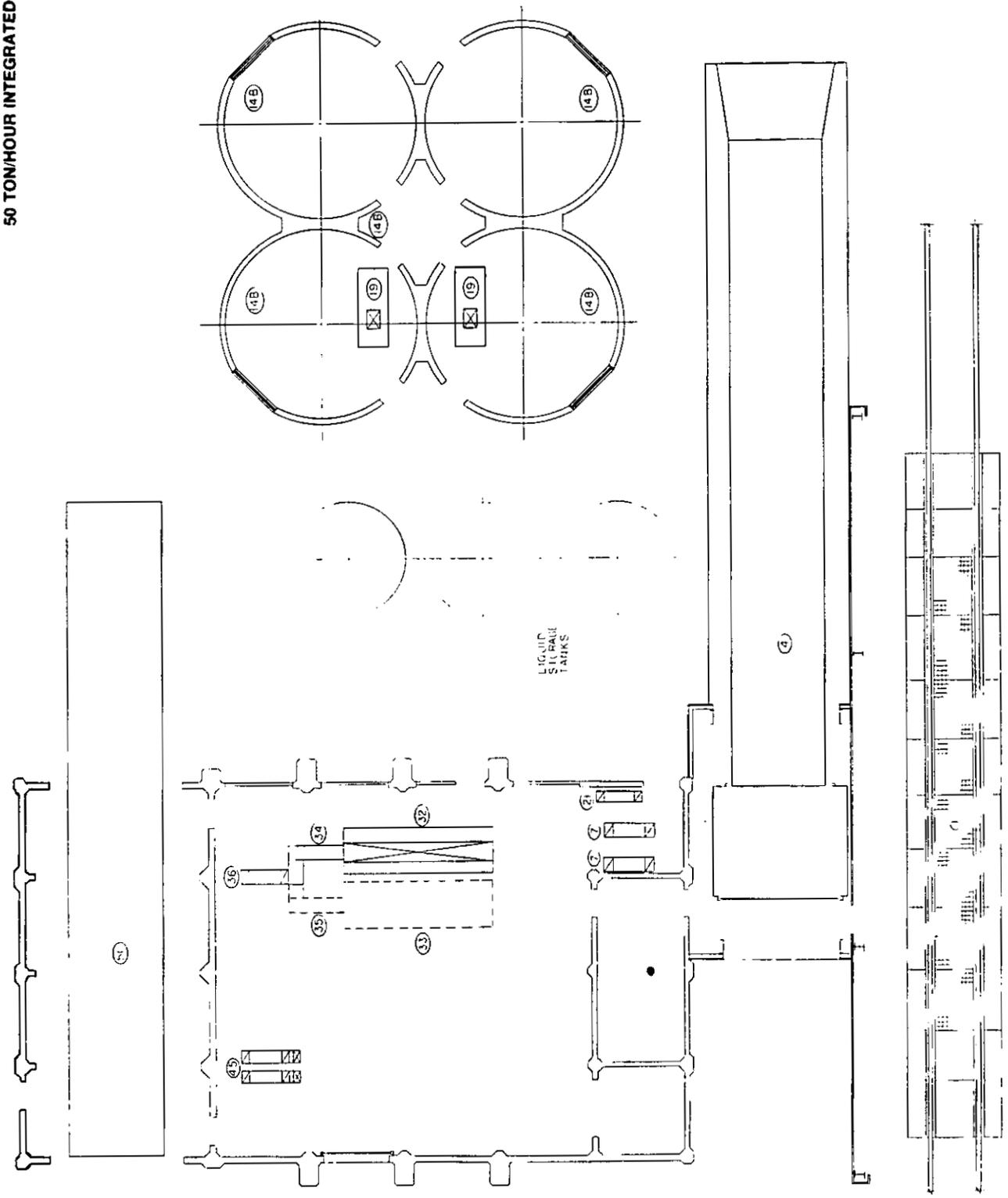


Fig. 5-14. First floor plan (Mill area, 40'x50'; Bulk feed bins, 40'x20').

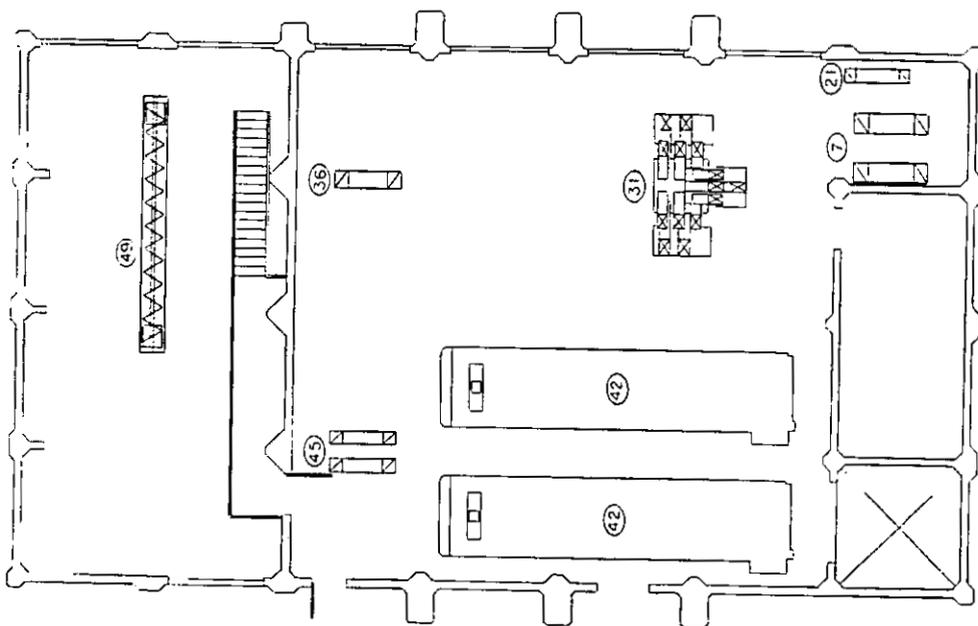


Fig. 5-15. Second floor plan (40'x70').

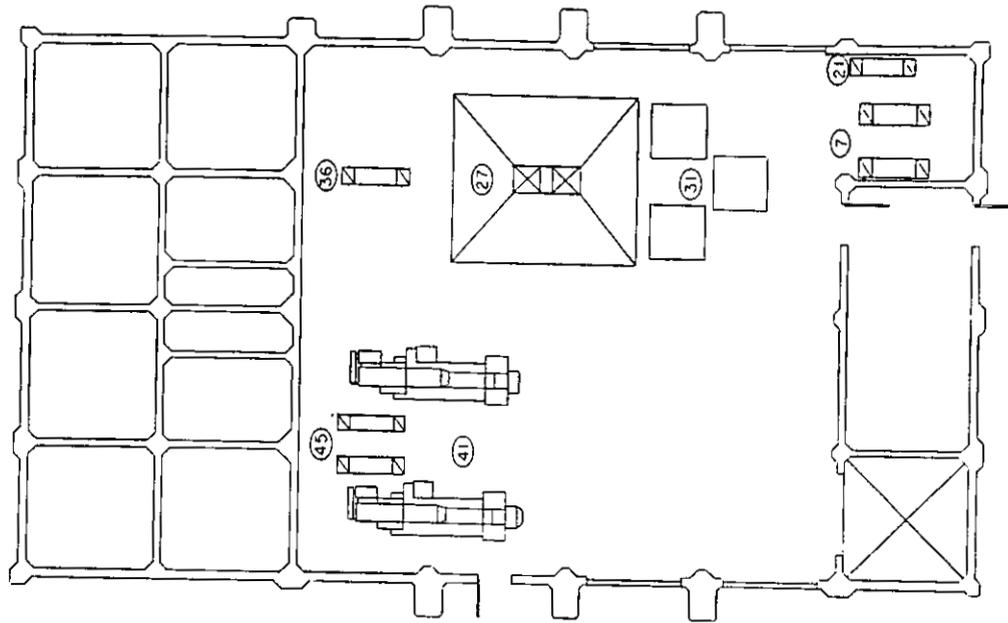


Fig. 5-16. Third floor plan (40'x70').

50 TON/HOUR INTEGRATED FEED PLANT

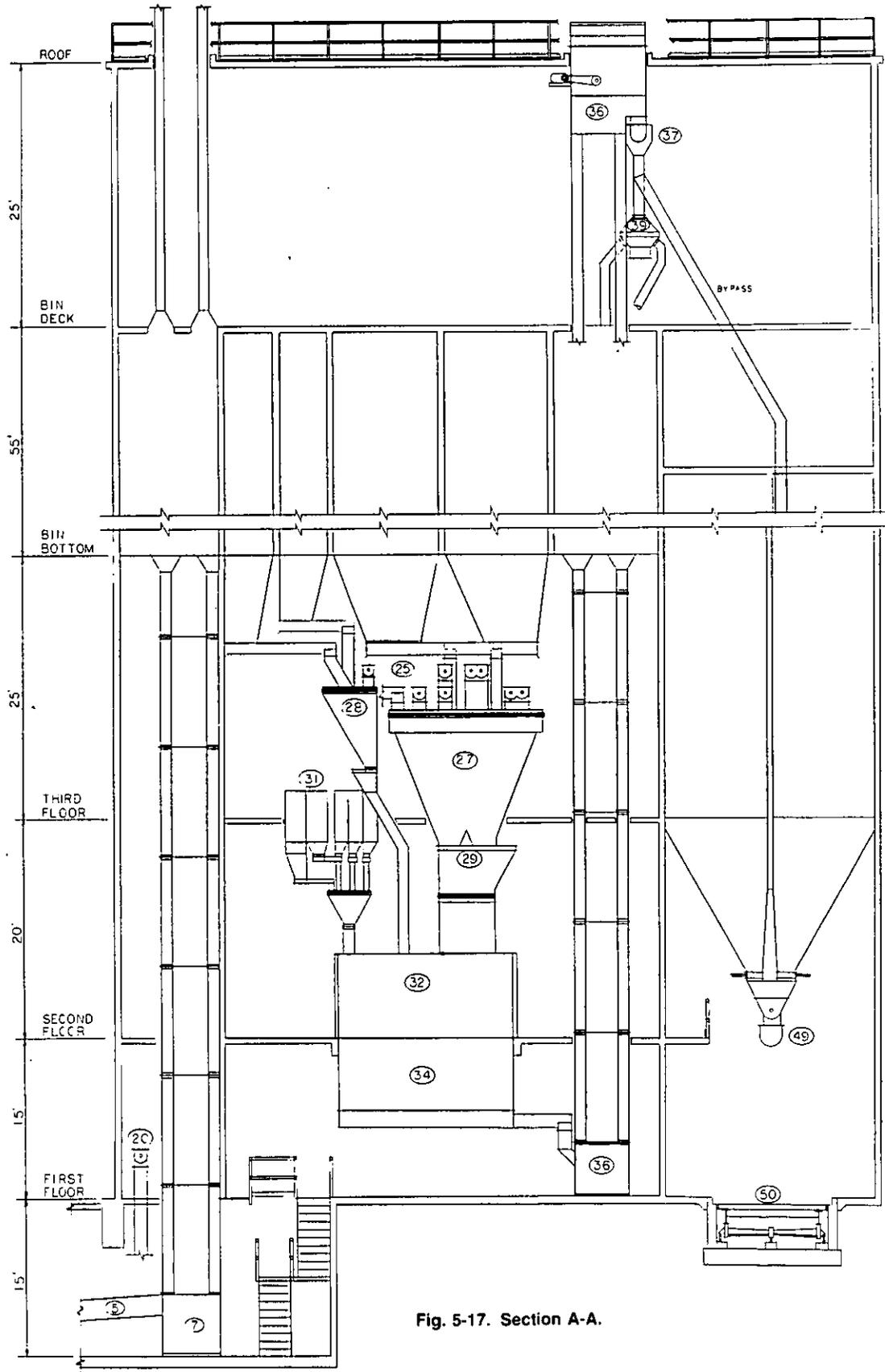


Fig. 5-17. Section A-A.

50 TON/HOUR INTEGRATED FEED PLANT

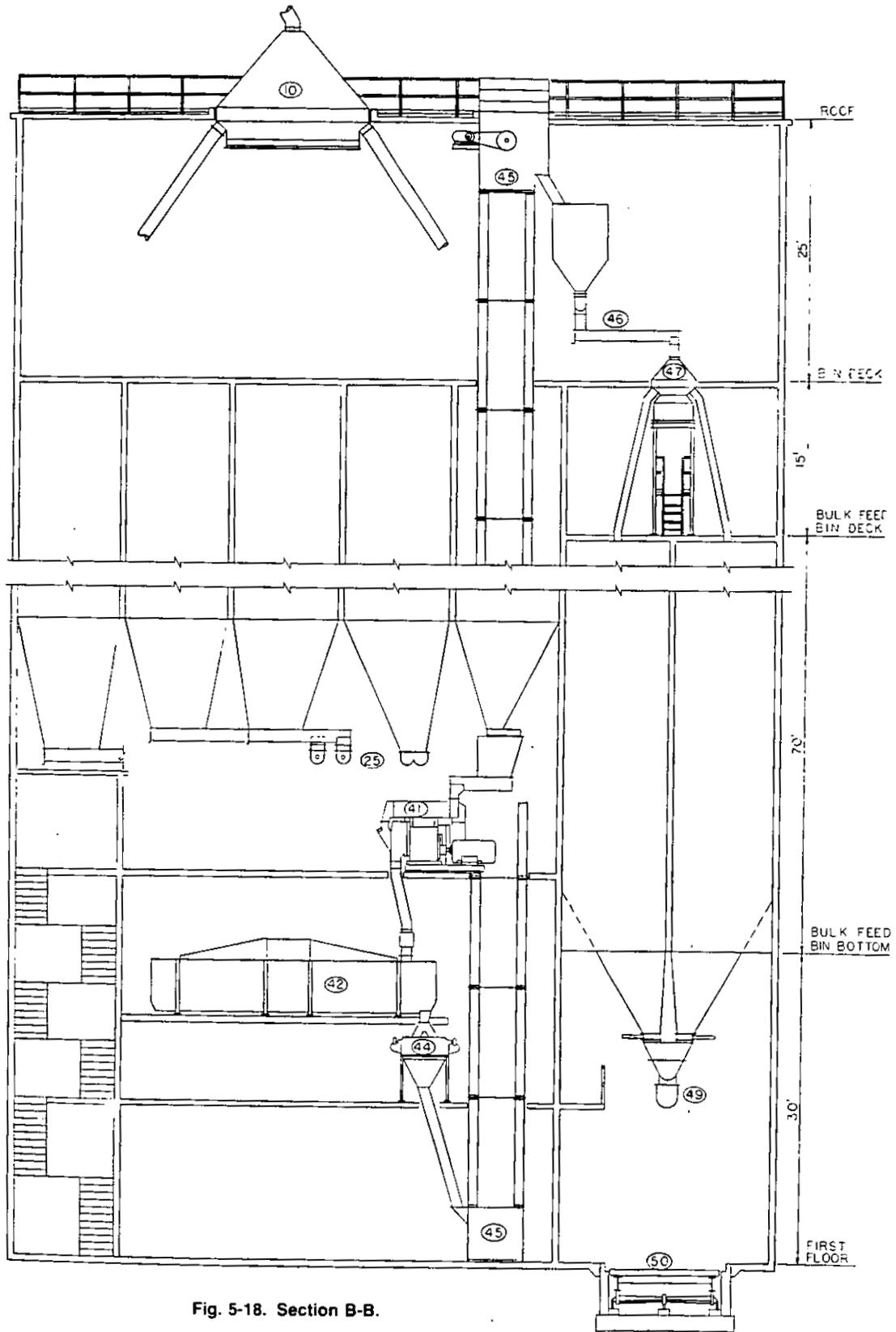


Fig. 5-18. Section B-B.

50 TON/HOUR INTEGRATED FEED PLANT

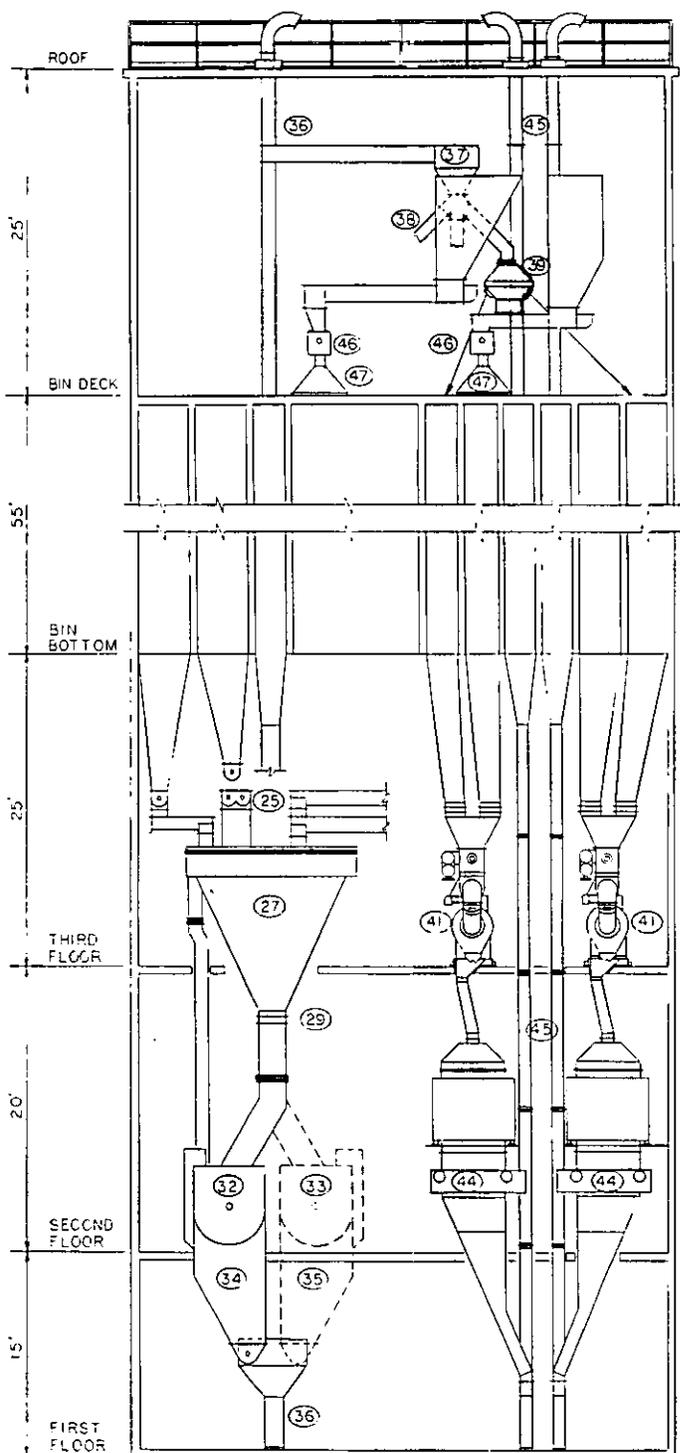


Fig. 5-19. Section C-C.

Storage and Ingredient Bin Design. Approximate amounts of each ingredient to be stored can only be determined from a knowledge of the rate of usage of each ingredient, size of loads, and knowledge of elapsed time between when an ingredient is ordered and when it is received.

The ingredient usage table shows the development of usage data to arrive at the number and size of ingredient bins. First, the ingredients usage was determined from the basic design criteria. The bin usage table was then prepared to show total ingredient storage to be provided. An adjustment was made in some of those values after the bin sizes were finally agreed upon. The actual cubic feet of storage assigned was converted to tons of storage, based on the density of the ingredient as shown. Then, the average days of storage was determined. By dividing the usage in tons per day by load size, the average loads per day of each ingredient and total loads per day can be determined.

Grinding. Grinding requirements may be up to 70% of the total production rate, or 35 tons per hour on an $\frac{3}{4}$ -inch or $\frac{1}{2}$ -inch screen. Since this plant is expected to produce 90% of its feed as broiler pellets or crumbles, most grinding will be fine. Some limited coarse grind may be required to produce nonpelleted breeder feeds. A single hammermill is generally not large enough to handle this requirement. Accordingly, two hammermills were selected. Less time is required for starting and stopping the mills, since they grind for longer periods with fewer screen changes required. There is some safety factor if one mill breaks down.

Hammermills were selected because a finer grind is required for the pelleted feed. Roller mills are not used as frequently for finely ground materials. Attrition mills were not considered.

Batch Weighing. Ingredients have been classified as major, minor, or micro according to the relative quantity generally required for a feed. Small quantities are difficult to accurately weigh on a large scale. For this reason, three scales have been provided: an 8000-lb scale for major ingredients, a 2000-lb scale for minor ingredients, and a 100-lb scale for microingredients. The major scale will handle the principal ingredients of corn, soybean meal, protein meals, and by-products. The 2000-lb scale can handle the minerals plus, possibly, some specialty protein products.

Microingredients. This design example includes an automatic bulk microingredient system. It does add to the initial cost of the plant; however, it provides better quality control, reduces labor, eliminates plant time for making premixes, and improves record keeping. Many poultry feed plant owners have found that its advantages make it a desirable and feasible option.

Mixing. One 4-ton mixer with surge bin was selected with provisions for a future 4-ton mixer. Mixing time is expected to require $\frac{1}{2}$ minute to charge the mixer from scale hoppers, 3 minutes mix time, and a maximum of $\frac{1}{2}$ minute to discharge the mixer into the surge bin. A 4-minute mix cycle provides for a gross output of 15 batches per hour, or 60 tons per hour. The net production is expected to be 50 tons per hour on a continuous basis.

Provision is made for adding liquids, including low levels of fat (up to 1%) in the mixer. Provision is also made for adding two other liquids — choline chloride and methionine. Some poultry plants utilize even more liquids. From the mixers, the feed is elevated to a distributor serving the pellet mash bins over the pellet mills. It also spouts to the bulk load-out bins.

Pelleting. Ninety percent production of pellets and crumbles requires two pellet mills. Two mash bins serve each of the mills. The pellets drop into a cooler directly under the mills. Crumble rolls are installed at the cooler discharge. Pellets and crumbles are elevated to the top of the mill as a finished feed. Most poultry mills serving integrated operations do not screen pellets and crumbles.

At the end of a run and after the cooler has been switched to

50 TON/HOUR INTEGRATED FEED PLANT

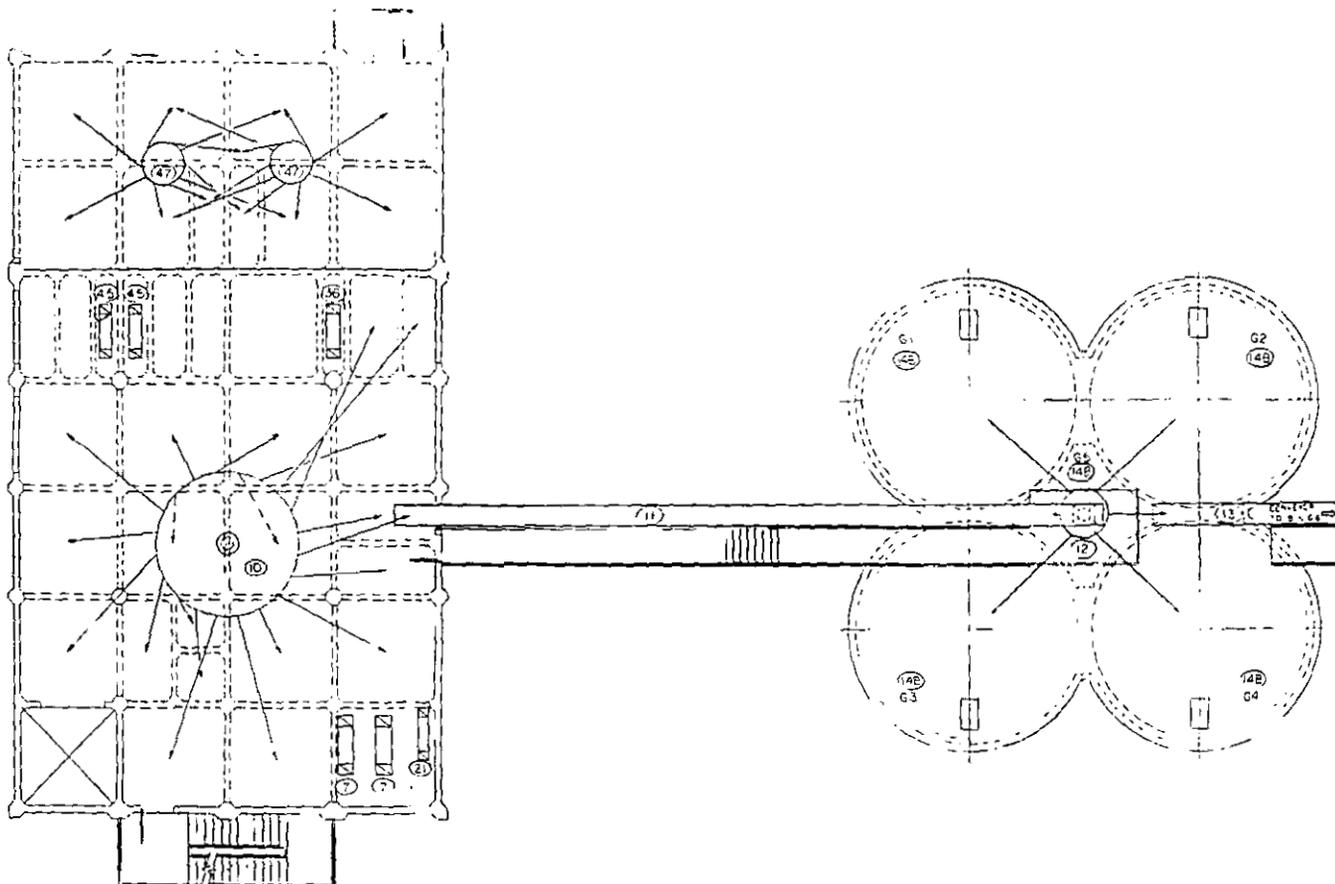


Fig. 5-20. Bin deck plan (40'x70').

manual continuous running to empty, special provision must be taken to prevent cross-contamination. If conveying is required, usually a drag type conveyor rather than a screw conveyor is used for horizontal conveying of pellets to minimize breakage and contamination.

Bulk Loadout. Ten bulk feed bins have been provided and are located over a driveway for bulk feed trucks. The two bulk feed distributors are spouted to eight bins each. That provides for six bins to receive pellets or crumbles from either pellet mill. Total storage is approximately 1000 tons, or about 1 1/4 days production.

Airgates on the bulk feed bins, a collecting conveyor, and a shuttle conveyor have been provided for bulk feed loadout. A truck scale is also located in the truck drive under the bins. This feature, together with the shuttle conveyor, will allow a truck to be fully loaded from one spotting and weighed by compartment loads.

High Fat Pellets. An automatic fat coater with surge bin, feeder, and blender is provided for adding up to 7% fat to the outside of the pellets and crumbles. The feeder will meter the pellets or crumbles at a constant rate. A variable speed fat pump and a fat meter control the rate of fat to suit the desired level. No by-pass around the fat coater is shown. This is a detail that could be added, or the fat coater could run without fat being added. Most poultry feed plants will always add some fat to pellets and crumbles, although it may be only about 1/2%.

Warehouse. The warehouse should be sized for storage of drugs and other bagged microingredients.

Auxiliary Systems. Generally, auxiliary equipment and systems get less attention than process equipment. Inadequate auxiliaries can cause the best of processing equipment to fail to meet their rated performance. For example, an adequate supply of dry steam is required to produce a high quality pellet on any pellet mill. Therefore, the correct size boiler and a well-designed steam distribution system are mandatory.

Dust Control. Dust control will be required to meet the requirements of the Environmental Protection Agency and state and local authorities having such jurisdiction. The design of dust control systems is covered in the publication "Environmental Controls for Feed Manufacturing and Grain Handling" published by the American Feed Industry Association.

Ample space has been provided in this design to install adequate dust control techniques.

Control Systems. Details were beyond the scope of this design example. However, a wide range of microprocessor (computer) based systems are available for automatic batching, inventory and record keeping, production records, routing, and pelletting. It is expected that an appropriate system would be specified to enhance the basic design capabilities and functions of this feed plant.

Table 5-2. INGREDIENT USAGE AND STORAGE OF 50 TON/HOUR INTEGRATED POULTRY PLANT.

Ingredient	Lbs. Per Cu. Ft.	Usage		Max. Load Size (Tons)	Min. Storage Desired (Days)	Storage Provided	
		%	TPD			Tons	Days
Corn	45	62	496	500 ⁽⁴⁾	10	5380	11
Soybean Meal	42	17	136	90	4	550	4
Poultry By-Product Meal	35	4.5	36	22	6	270	8
Bakery By-Product	40	3.5	28	20	6	240	9 ⁽³⁾
Gluten Meal	36	3	24	90	5	480	20 ⁽¹⁾
Fish Meal	44	3	24	22	5	120	5
Meat & Bone Meal	45	1.5	12	22	4	50	4
Blood Meal	45	0.5	4	20	6	50	13 ⁽³⁾
Phosphate	70	1	8	90	5	280 ⁽²⁾	36 ⁽¹⁾⁽²⁾
Limestone	85	0.4	3.2	22	5	40	17 ⁽¹⁾
Salt	80	0.1	0.8	22	5	35	44 ⁽¹⁾
Liquids	—	3.1	24.8	20			
Micros	—	0.4	3.2	—			
Total		100.0	800.0				

⁽¹⁾ Storage Provided was controlled by load size, resulting in more days storage than minimum desired.

⁽²⁾ Two types of phosphate to be handled.

⁽³⁾ Excess storage, but controlled by bin space allocation and bin splits.

⁽⁴⁾ 5 Car Multi.

Table 5-3. INGREDIENT BIN ALLOCATION 50 TON/HOUR INTEGRATED POULTRY PLANT.

Ingredient	Outside Bins (Tons)	Inside Bins (Tons)	Total (Tons)
Corn	5200	180	5380
Soybean Meal	450	100	550
Poultry			
By-Product Meal	0	270	270
Bakery By-Product	0	240	240
Gluten Meal	400	80	480
Fish Meal	0	120	120
Meat and			
Bone Meal	0	50	50
Blood Meal	0	50	50
Phosphate	0	280	280
Limestone	0	40	40
Salt	0	35	35
Utility	125	240	365
Total⁽¹⁾	6175	1685	7860

⁽¹⁾ Excludes Liquids and Micros

Dust Collection Systems

Gary L. McDaniel
MAC Equipment, Inc.

A dust collection system serves many purposes. Good housekeeping in conjunction with proper dust control will reduce insect and rodent problems and other hazardous contaminants. The benefits of clean working conditions will outweigh the costs in the long run because the employer will maintain a more experienced, efficient staff and will be able to meet the requirements of OSHA much easier.

Good housekeeping could also result in a lower insurance rate. The insurance rate is determined by the general housekeeping and appearance of a facility, and some companies will give a lower rate for the installation of an adequate dust control system. If a plant has an adequate dust control system, housekeeping will be accomplished with less effort and fewer man hours spent. Some insurance companies will not insure facilities that do not have pneumatic dust control systems that meet their standards.

Dust control can reduce loss or shrinkage of the product being handled by controlling dust emission points either by containment or aspiration. Captured dust can be returned to the stock handling system or collected in a dust bin and utilized later. Reduced shrinkage can add to the profit of a company.

Many studies have been conducted and information has been gathered on dust explosions in elevators and feed plants.

What causes a dust explosion? A grain dust explosion can occur only if four factors co-exist: oxygen, an ignition source, a confined volume, and suspended dust. Eliminating any one of the factors will eliminate the possibility of explosion; however, this is easier said than done. Since the first three factors are somewhat uncontrollable, researchers and manufacturers look toward dust control to lower the chances of dust explosions. For a general definition of terms applied to dust collection systems, see Appendix A.

DUST PRODUCING POINTS

Dust producing points in a typical feed plant include the receiving areas, hammermills, roller mills and crimpers, mixing system, elevator legs and distributors, screw and drag conveyors, belt conveyors, pellet scalpers, baggers, and loadout areas.

Receiving Area

Truck and rail receiving areas are a source of dust emissions in the feed plant. Since many receiving areas are not fully enclosed, fugitive and nuisance dust results. Controlling dust in receiving areas is difficult because of the variety of trucks and rail vehicles. Trucks consist of semitrailers with fixed bodies, semitrailers with self-dumping bodies, short trucks with both fixed and self-dumping bodies, and hopper bottom trailers. Railcars consist of hopper bottom cars and box cars. It is difficult to design a receiving area to accommodate all units.

Most feed plants have some type of receiving pit or dump pit. It may be enclosed, partially enclosed, or totally enclosed. If it is an unenclosed area, the effect of wind, a major contributing factor to dust problems in receiving areas, must be taken into account. Wind can be of a magnitude that is impractical to combat with a dust suction system. Capture velocities in the range of 150 to 250 ft/min function adequately under static conditions. However, as can be noted from the following chart, a 10-mile per hour wind is equivalent to a velocity of 880 ft/min.

Wind (mi/h)	Velocity
5	440
10	880
20	1760
30	2640

It is not practical to capture dust with a dust suction system in a receiving area if the wind is of any magnitude at all. Wind should not be fought with air. It is advised that all receiving areas have some type of enclosure. The feed plant operator must give consideration to some type of enclosure for dust suction to be effective (Figure 13-1). A partial enclosure can be effective in areas of limited or small wind velocities. A total enclosure is the best choice. Total enclosure will ensure the feed plant operator of an adequate, efficient dust control system under all conditions.

There are two methods of controlling dust at a receiving pit. Dust pickup below the grate is effective on large deep pits, whereas dust pickup above the grate is recommended for shallow pits. Suction below the grate works well on large pits in which the

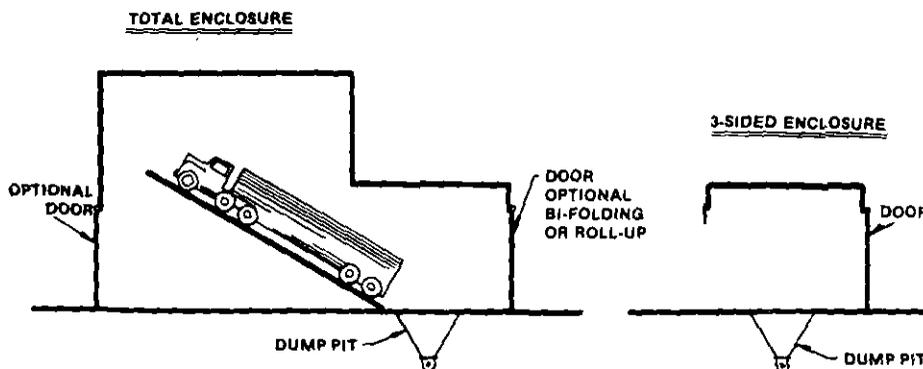


Fig. 13-1. Receiving enclosure.

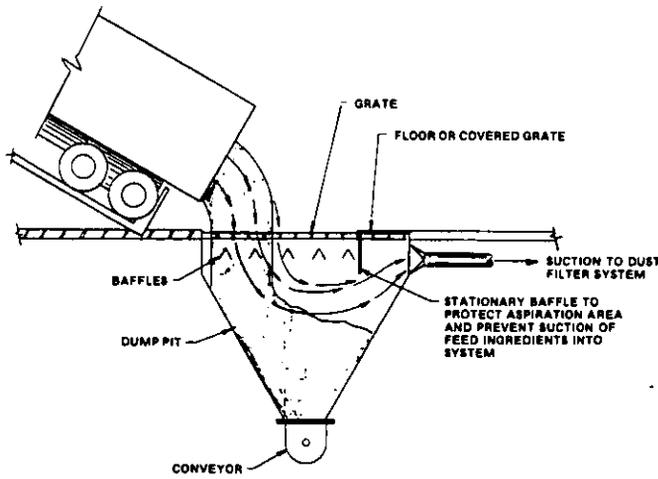


Fig. 13-2. Below grate dump pit dust pickup.

ingredients do not build up above grate level when dumping (Figure 13-2). Suction should be installed into the pit area where it will not draw ingredients into the dust system. This possibility can be reduced by installing a stationary baffle to provide an area in the dump pit into which the ingredients cannot flow. When sizing a system for below the grate pickup, 150 cfm per square foot of open grate area is recommended. For example, if the grate is 10 ft by 10 ft, the flow rate recommended is:

$$100 \text{ sq ft} \times 150 \text{ cfm/sq ft} = 15,000 \text{ cfm}$$

The flow rate can be reduced by installing baffles below the grate, reducing the effective open area. The open area can be reduced 50 to 60% with baffles and still maintain adequate openings for ingredient flow. If, in the example above, baffles are installed to reduce the open area by 50%, the air volume can be reduced to 7,500 cfm.

For shallow pits (Figure 13-3), the pickup points should be located at floor level on both sides of the driveway or, in the case of a back-up dump pit, can be located at the back of the grate. The

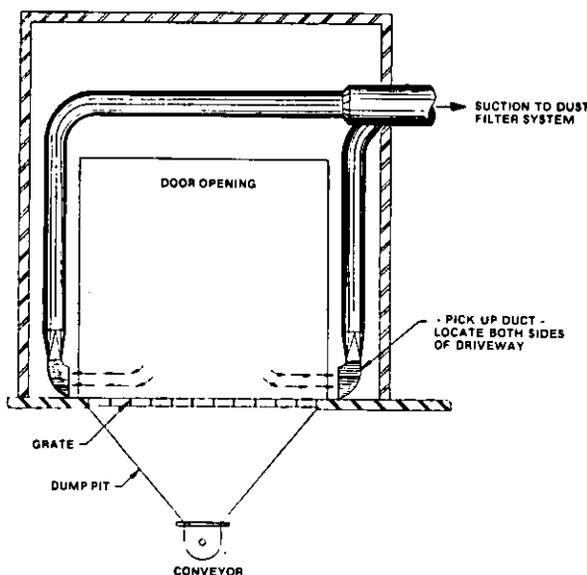


Fig. 13-3. Above grate dump pit dust pickup.

pickup hoods should be located as close to the grate as possible without obstructing the trucks or railcars. It is recommended the system be designed for 10,000 to 15,000 cfm air volume. There must be a judgment decision on the part of the designer, giving consideration to the type of enclosure, how close the pickup point are to the grate, how large the grate is, and what type of vehicle dumping. A hopper dump vehicle does not generate as much dust as a tail dump.

Hopper dump units generate the least amount of dust if the gate is fully opened and the dump pit is choke fed. Do not run partially open gate. If the unit is choke fed, the only dust emission are when the gate is initially opened (Figure 13-4). An above-the-grate pickup is effective in controlling dust for hopper dump truck or railcars.

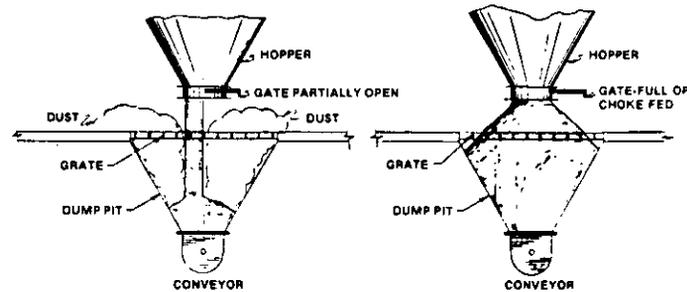


Fig. 13-4. Hopper dump.

It is recommended that aspiration be applied on a floor dump above the grate (Figure 13-5). For practical purposes, a below-the-grate pickup would inhale material into the pickup point. To be effective with a minimum amount of air, it is necessary to enclose as much of the grate as possible. Three sides should be enclosed if possible. For an above-the-grate pickup, use 125 to 200 cfm of air per square foot of grate area. For example, a grate 2 ft by 2 ft would equal 4 square feet of area. Therefore:

$$4 \text{ sq ft} \times 150 \text{ cfm/sq ft} = 600 \text{ cfm}$$

To use the air most effectively, a pickup should be as close to the grate as possible at the back side of the hood; however, another method that has been used frequently is to install the pickup point at the top of the hood (Figure 13-6). Positioning the pickup at the

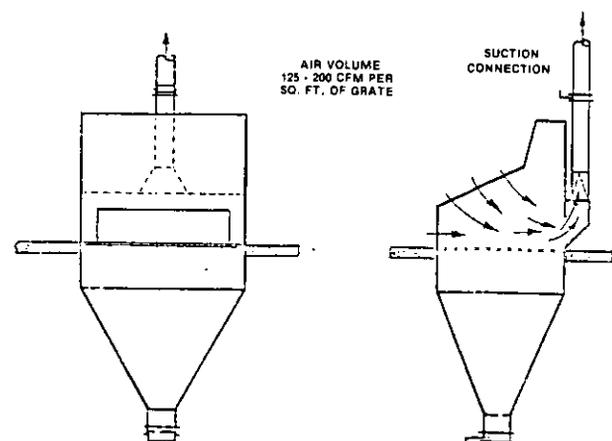
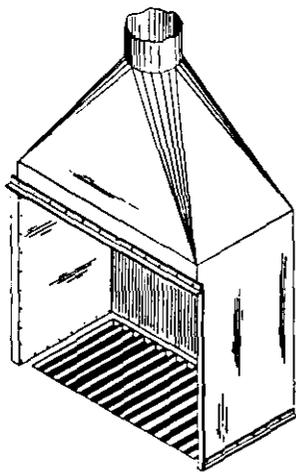


Fig. 13-5. Floor dump.



- NOTES:**
- 1.) DIMENSIONS:
HEIGHT OF OPENING - 30" OR LESS
DEPTH - FULL WIDTH OF FLOOR OPENING OR MORE
LENGTH - FULL LENGTH OF FLOOR OPENING OR MORE
 - 2.) AIR VOLUME:
100 CFM FOR EACH SQUARE FOOT OF FRONT OPENING
 - 3.) TAKEN FROM MILL MUTUAL FIRE PREVENTION BUREAU

Fig. 13-6. Standard hood for floor dump opening.

of the hood, however, tends to use more cfm per square foot of grate as opposed to positioning it at the back side of the hood, as close to the grate as possible.

Conveying Equipment

Elevator legs and distributors deserve considerable attention because it is at this point where much controversy arises. The controversy is created by the fact that the elevator leg has been the origination of almost all dust explosions in the past years. There are two points to deal with on an elevator leg — the boot and the head. There are two reasons why internal pressure is created within an elevator boot. When the elevator boot is being filled with ingredients, air is displaced. Also, the movement of the cups in the down side of the leg are acting as an air pump causing air movement into the boot section.

At the elevator head, the emptying of the buckets tends to cause a reduction of air pressure within the head section. Under normal conditions, pressures within the elevator head tend to be slightly below atmospheric; however, other factors may affect the head section. If the head discharges through a spout to a tight bin or distributor, the air displaced in the distributor will have to come back up the spout in the direction opposite to that of the ingredient movement. The counterflow of air will carry a considerable volume of dust back into the elevator heads resulting in puffs of dust laden air being blown out of the openings of the head section. That problem can be eliminated by applying aspiration on the up leg above the boot section and by proper venting of bins and distributor.

Past practice has been to place the prime air pickup point on top of the boot and side of the head. This provides enough suction to keep the leg under negative pressure. One of the problems with that type of thinking was that the leg was probably still well above the minimum explosive limit. In addition, the designer was also fighting the natural movement of air created by the belt and buckets plus the pressure from the entrained air entering through the feed inlet and, thus, was probably creating a greater dust concentration in the leg where the buckets are being filled and exiting the boot section.

MAC Equipment has conducted research on elevators and has concluded that the most efficient use of aspiration is on the up side of the leg above the boot section as opposed to the top of the boot. Those studies also concluded that, with increased aspiration,

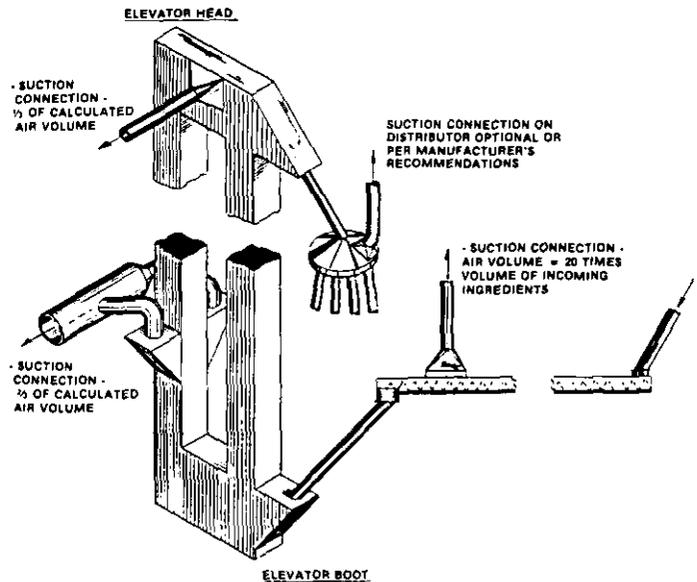


Fig. 13-7. Elevator leg.

the dust concentration is lowered. When applying this method to a feed ingredient leg, care must be taken not to draw too high a percentage of ingredients from the leg (Figure 13-7).

In fact, tests on legs handling whole grain prove that dust concentrations can be reduced below the minimum explosive limit by using this simple formula to determine cfm:

$$\text{Area of leg in sq ft} \times \text{ft/min of belt travel} \times 1.25 = \text{minimum explosive limit}$$

For example:

$$4 \text{ sq ft} \times 500 \text{ ft/min} \times 1.25 = 2500 \text{ cfm}$$

MAC's recommendation is to apply one-third of the total cfm to the head section if the leg is over 90 ft tall and two-thirds to the boot area, specifically, to the up side of the leg above the boot section.

Generally speaking, screw and drag conveyors do not produce great amounts of dust; however, even a minimal amount of dust should be given consideration. Most of the dust is produced at the inlet point where the ingredients are fed onto the conveyor. Air and dust enters the housing of the conveyor; therefore, the housing must be vented to relieve the internal pressure. MAC also recommends using the volume of the incoming ingredients times 20 to determine cfm, since the air entrained with the flowing ingredients is considerably more than most people believe it to be. For example, a conveyor handling 15 tons per hour calculates to:

$$12.5 \text{ cfm} \times 20 = 250 \text{ cfm}$$

Belt conveyors produce dust at the loading point where the product is spouted onto the belt (Figure 13-8). A common hood can be provided for receiving the product and for a dust suction connection. The design of the hood is somewhat dependent on belt speed. Assuming a belt speed of 500 to 600 ft/min, a total length of 4 ft is recommended. The discharge end of the hood should provide approximately 3 in. clearance above the belt for the product to pass. The sides of the hood should be fitted with flexible flashing to hold the minimum clearance to the belt. Use 250 to 350 cfm per foot of belt width. The cfm is dependent on the belt speed. The faster the belt runs, the more cfm that is required to capture the dust.

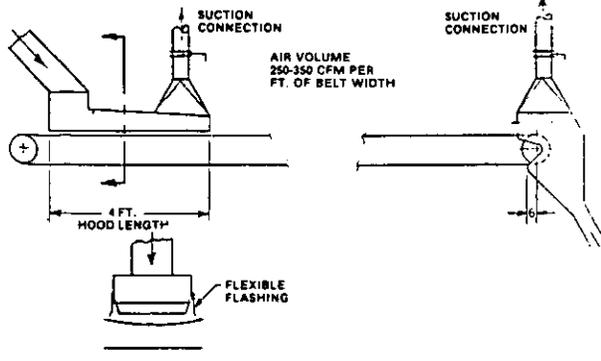


Fig. 13-8. Belt conveyor.

Belt speeds below 500 ft/min may use the low range; but for belt speeds above 500 ft/min, the high range is recommended. For example, a 2 ft wide belt would equal two times 350 cfm or 700 cfm. As the ingredients are discharged from the discharge end of the belt, dust will distribute itself around the general area. In addition, dust and ingredient particles adhere to the belt after the ingredient is discharged, and they are carried around the head pulley of the conveyor. When building a discharge dust hood, enclose the discharge end of the conveyor and extend past the centerline of the head pulley by a minimum of 6 in. A suction hood should be installed on top of the discharge hood using the same cfm per belt width as above.

Storage — Venting of Bins

It is commonly understood that a bin being filled from a gravity flow feed spout requires venting. The area that is not totally understood is that of determining how much air must be removed from such bins.

Many designers allow for the volume of air displaced by the incoming product, but very few allow for the entrained air in the material column. The entrained air volume must be considered in the design if adequate and effective venting is to be accomplished.

The desired design parameter is to remove all the incoming (entrained) air and, in addition, maintain the bin at a slightly negative pressure. This will assure that the direction of air flow is into the bin at all times and will effectively eliminate dusting from it.

To determine the amount of entrained air within a vertical column of falling material, the formula in Table 13-1 can be applied. For example, a 6 in. diameter spout of 0.196 sq ft and 5 ft long is transferring 20,000 lbs/hr of cracked corn at 56 lbs/cu ft and the particle size is 3/16 in.

This formula takes into account the energy given up by the falling material that generates the entrained air as applied to a vertical falling stream. That volume can be reduced to the following for inclined spouts.

- 90° spout = 100%
- 80° spout = 91%
- 70° spout = 82%
- 60° spout = 65%
- 50° spout = 49%

For all additional open areas on the bin deck, design the incoming air velocity at a minimum of 100 ft/min. The bin shown in Figure 13-9 can be vented in one of four methods or variations of them.

Table 13-1. ENTRAINED AIR WITHIN A VERTICAL COLUMN OF FALLING MATERIAL.

$$CFM = \sqrt[3]{\frac{\left(\frac{A}{3600}\right) (B^2) (C^2) (.22 \times 10^{11})}{\left(\frac{D}{84.4}\right) \left[\frac{E}{12} (3.05 \times 10^5)\right]}}$$

Where:

- A = Material flow in pounds per hour
- B = Effective length of spout in ft
- C = Spout area in square feet
- D = Material density in pounds per sq ft
- E = Material particle size in inches

EXAMPLE —

$$CFM = \sqrt[3]{\frac{\left(\frac{20,000}{3,600}\right) (5^2) (.087^2) (.22 \times 10^{11})}{\left(\frac{56}{84.4}\right) \left[\frac{.187}{12} (3.05 \times 10^5)\right]}}$$

305 CFM to be vented from bin

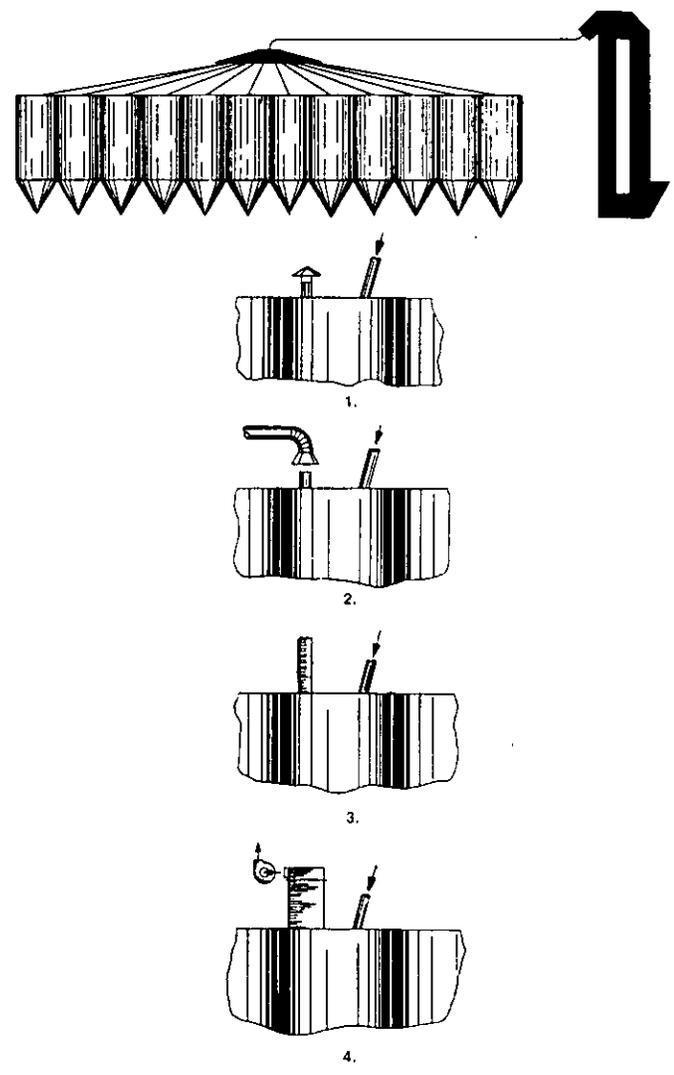


Fig. 13-9. Venting of bins.

1. An open vent stub with only a weatherhood for protection. There is little that needs to be said for this system. It relieves the positive pressure and relieves all the fines to the atmosphere. This is not an acceptable method for most users from a standpoint of their own housecleaning, from neighbors, or from OSHA acceptance.
2. A vent line from the enclosed bin to an existing dust collection system. This appears to be a simple solution, but it usually fails to be acceptable in the long term. The major disadvantage is, if the vent line is applied as illustrated, it will remove all vented air from the bin but maintain a high volume of air through the duct at all times, whether the bin is being filled or not.
3. A manually cleaned vent sock. This system often does not eliminate dusting. The spout entry to the bin and the bin deck must be sealed, as the bin is always under positive pressure. The cleaner the bag, the better the venting action. The longer the bag goes unattended, the greater the positive pressure within the bin and the more likely that dusting will occur. Manually cleaned vent socks should be sized at 4:1 air-to-cloth.
4. A compressed air filter with a suction fan. Its ability to self clean and maintain the bin under a slightly negative pressure provides the desired design condition and makes it the most effective method. Sizing the filter is typically at 10:1 air-to-cloth ratio for feed grains without additives that are adhesive or cohesive. With those additives present, the air-to-cloth ratio should be decreased to 8:1. The suction fan should be sized at the design cfm and a negative 5-in. water gauge (wg). This is a closed system that returns all dust to the bin it came from with no material loss.

Cleaning Equipment

By the time feed gets to the pellet scalper, there is usually very little dust left (Figure 13-10). However, the pellet scalper shakes the ingredients, separating the fines from the pellets. Any dust that is present mushrooms out into the surrounding area. It is recommended that a lightweight hood be built over the pellet scalper. It should be light enough in weight so that it does not affect

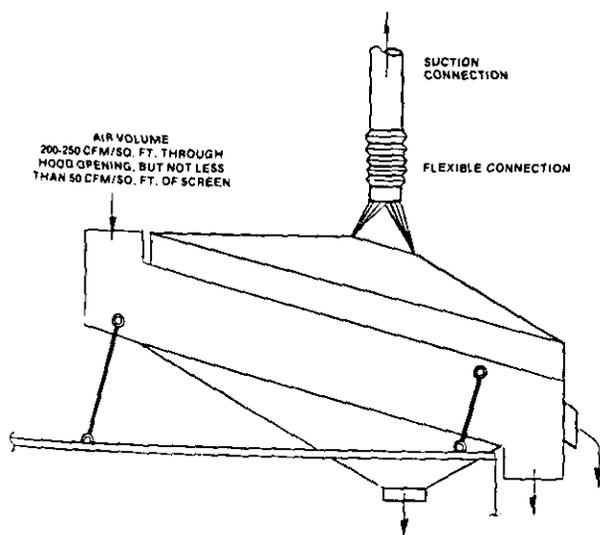


Fig. 13-10. Pellet scalper.

the shaking action of the unit, and a flexible hose is required to compensate for the movement. Cfm can be determined by the open area available through the scalper mechanism. This is usually the product inlet area and the product discharge. Use of 250 cfm per square foot of open area is recommended. For example, if the scalper has a 12 in. square inlet and a 12 in. square outlet, that gives a total of 2 square feet. Therefore.

$$250 \text{ cfm/sq ft} \times 2 \text{ sq ft} = 500 \text{ cfm}$$

Processing Equipment

The processing equipment used in a feed plant includes full circle and/or conventional hammermills, a mixing system, roller mills, crimpers, pellet mills, and coolers. CAUTION: Probably the most hazardous piece of equipment in the feed plant is the hammermill because of its high speed. It has the potential of producing sparks from foreign objects. Those sparks carry through the stock handling system and start fires or are potential dust explosion hazards. When designing a new feed plant, consideration should be given to locating the hammermill outside.

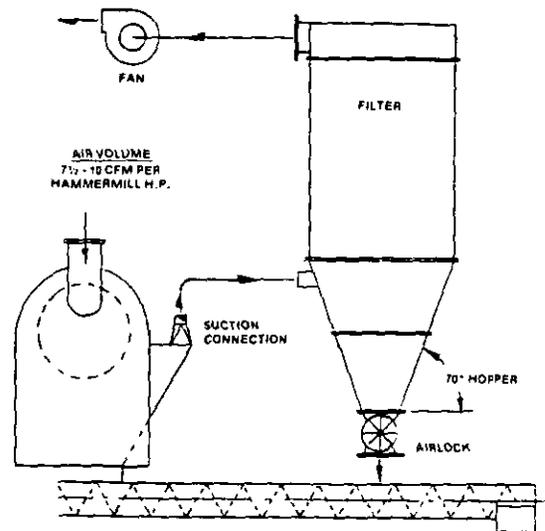


Fig. 13-11. Full circle hammermill.

Full circle hammermills should be vented (Figure 13-11). First, the rotor of a mill turning at high speeds produces a centrifugal fan action, pressurizing the hammermill housing. Venting will help alleviate dust belching out of the housing inlet, outlet, or any opening. Secondly, when grinding grain, there is a moisture release and temperature increase due to friction. If the air is not vented, moisture will condense in the lower portion of the mill housing and the conveyor to cause rusting and corrosion. In addition, it is possible for the temperature to build up around 150°F in the housing. The combination of temperature with condensed moisture causes the product to become very sticky and handling problems result. It is recommended that 7½ to 10 cfm per hammermill hp be used for venting a full circle mill. For example, a 100 hp mill would take 100 times 10 cfm or 1000 cfm. Because of the high moisture released and assuming a filter is being used, a 70° hopper on the filter is recommended to eliminate bridging and plugging. Emissions from the air lift of a conventional hammermill

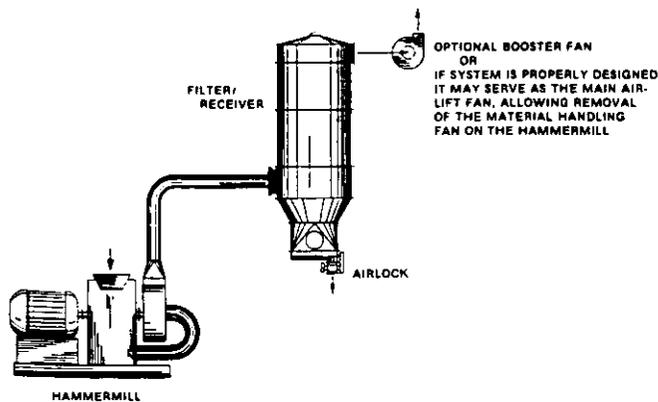


Fig. 13-12. Conventional hammermill — primary filter system.

may be handled in two ways. A primary filter receiver (Figure 13-12) with a tangential inlet will handle the greatest volume of stock. An airlock for discharge of the hopper must be sized to accommodate the maximum output of each hammermill.

Emissions can also be controlled by a primary-secondary system (Figure 13-13). In a primary-secondary system, a cyclone is used as the primary receiver and a filter as the secondary receiver. An airlock must be installed on the primary cyclone with the air flow taken to the filter receiver. The advantage of the primary-secondary system is that wear is on the cyclone, which is less expensive to maintain than the filter receiver. To offset the additional static pressure of the filter, a booster fan may be needed. Filter resistance will run 3 to 5 in. wg on properly applied filters. If a booster fan is added, consideration may be given to incorporating it as the main airlift fan and removing the material handling fan from the hammermill.

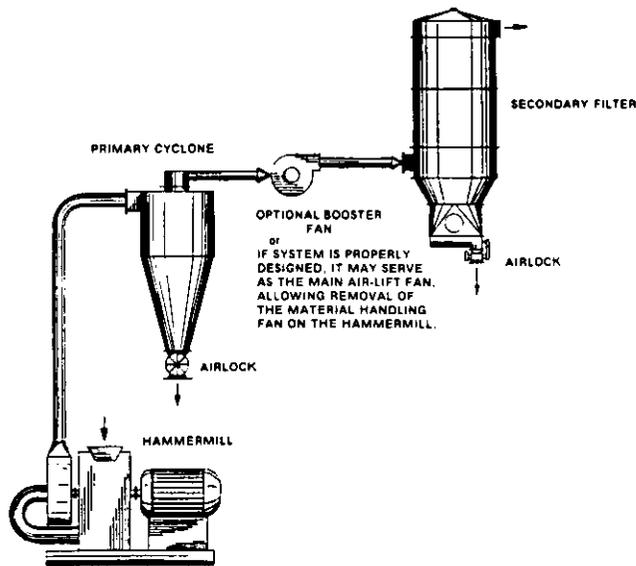


Fig. 13-13. Conventional hammermill — primary secondary system.

When sizing a filter for a hammermill system, a maximum of 9:1 air-to-cloth ratio is suggested. The hammermill system must be surveyed to determine the proper cfm of air.

The mixing system in a feed plant usually includes an upper scale hopper, batch mixer, and surge bin (Figure 13-14). Filling the

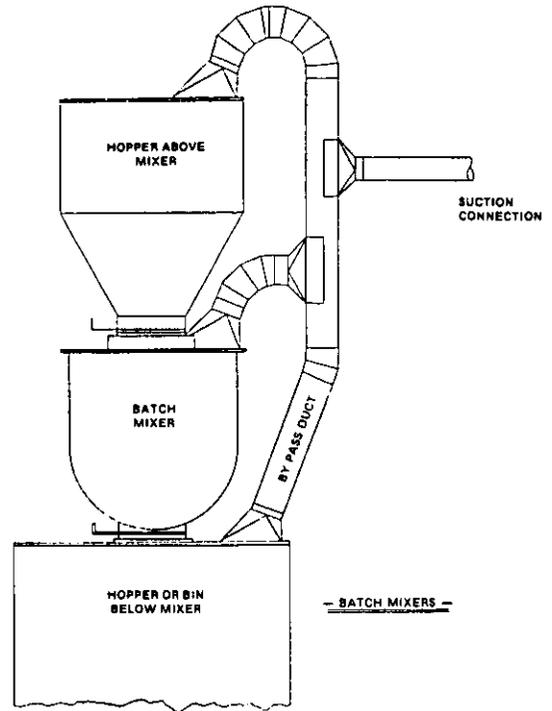


Fig. 13-14. Mixing system.

scale hopper with material tends to create internal pressure in the scale as well as when material is dropped from the mixer into the surge hopper. Internal pressure in all of these units causes dust laden air to blow out around gates and through openings causing dust conditions in the vicinity of the mixing equipment. Internal pressures can be relieved effectively by means of a by-pass duct connected to the dust control system. From the duct, a suction connection will be effective in further reducing the escape of dust from the mixing equipment. For example, a 2-ton mixing system will use a 7-in. diameter pickup duct in combination with a 10-in. by-pass duct for a velocity of 4000 fpm (minimum air velocity required to move the particulates in the air stream) or 1060 cfm.

A roller mill that is producing steam flaked grain will not produce much dust; however, a dry roller mill has many dust producing points. There are two means of controlling the emitted dust. First, aspiration of the housing can be effective with consideration given to the size of the roller mill. A minimum of 400 cfm and a maximum of 1000 cfm would generally be adequate to aspirate the housing. Another commonly used method is an exterior hood. It should be designed to adequately cover the dust producing points and to fit as closely as possible to the roller mill. The face area of the hood times 200 to 250 cfm is required. If the face area of the hood is 2 ft by 2 ft, then:

$$4 \text{ sq ft} \times 250 \text{ cfm/sq ft} = 1000 \text{ cfm/sq ft}$$

Bagging and Packing Equipment

Dust is generated at several points in the bagging system (Figure 13-15): as the bag is being filled, at the sewing head, and as the bag is pulled to go through the sewing machine. Building hoods that will enclose the unit enough to achieve total dust control are impossible because the operator would be visually handicapped. The other option is to use a large volume of air.

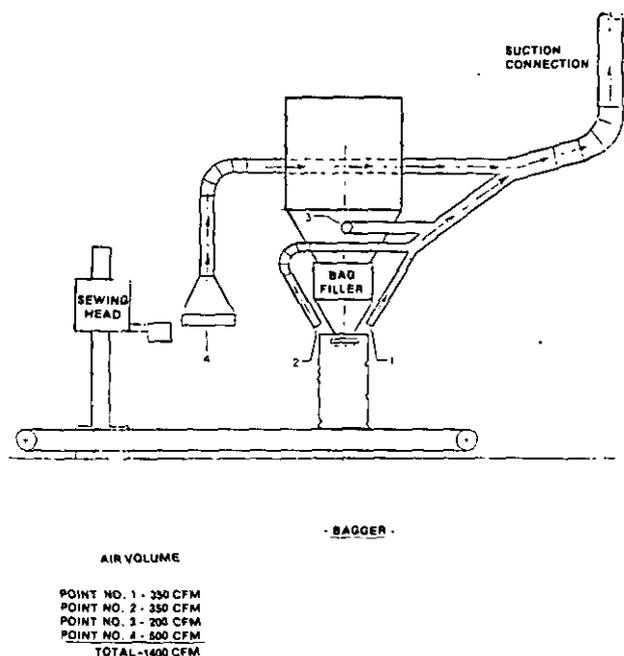


Fig. 13-15. Bagging and packing equipment.

Three pickup air volume points are mandatory with a fourth highly recommended. A pickup at both sides of the bag clamps just above the bags will capture dust escaping from the bags. A suction connection on the bagging hopper tends to hold the dust in suspension inside the unit after the filled bag is released. Those three points will control 85% of the dust created by the bagging operation; however, a fourth point is recommended. It should be installed just prior to the sewing head to capture the dust that is exhausted from the bags as the bag enters the sewing head.

There is no specific rule of thumb for determining the cfm on a bagging unit. The following recommendation has proven to be practical and satisfactory. For the first two pickup points, use a 4-in. diameter duct with 350 cfm on each; point No. 3 uses a 3-in. diameter duct with 200 cfm and the total for the three points is 900 cfm. If a fourth pickup point is added, use a 5-in. duct with 500 cfm.

Now that the pickup points have been defined and proper cfm has been determined for each, a dust filter(s) can be selected. Collected dust can be reused or disposed of depending on the content.

Loadout Area

Numerous attempts have been made with dust control systems trying to aspirate loadout areas. Large volumes of air are required due to the variety of truck heights, types, and styles. It is difficult to design a system that will accommodate all units. Only a small percentage of dust control systems installed in loadout areas have actually accomplished what the feed plant operator intended.

For controlling emissions at the loadout area, a total enclosure of the area with doors at both ends should be considered and socks should be attached to all spouts to eliminate or reduce free fall. Total enclosure, in conjunction with the socks, would contain the dust within the loadout area although frequent housekeeping

would be required. A pneumatic dust control system could be applied to the enclosure to further control fugitive dust.

To keep the area relatively dust free, the dust control system must be designed so that the air within the enclosure turns every 2 minutes or a minimum of 10,000 cfm. To be most effective, the pickup points should be located at floor level. Many designers make the mistake of placing the pickups at the top of the structure. Dust settling to the floor is easier to capture at floor level than trying to draw it up and into the system. The same volume of air will be more effective at floor level.

For further information, particularly dealing with high volume loadout, it is recommended that the designer obtain the manual, "Dust Control for Grain Elevators," from the National Grain and Feed Association, Washington, D.C., and read the chapter "Minimizing Dust Emissions During Truck and Rail Loadout." There are also many other good design practices outlined in the manual.

DUST COLLECTING DEVICES

There are several basic types of dust control systems. A negative pressure system includes all components handling dust-laden air under negative pressure. The advantages of this system are that any air leakage of dust-laden air from old or damaged ducting does not produce a dust emission point. One fan drives the entire system, which normally reduces installation, equipment, and energy costs. However, a negative pressure system can be disadvantageous where systems are large and pulling air from many points through the plant. All must operate if any are needed.

The second type of dust control system is the negative-positive pressure combination system. This system utilizes negative pressure to capture the dust-laden air at the pickup hood and into the ducting but then passes through the fan and is blown by positive pressure into the filter. The advantages include the adaptability of this system where multiple pickup points are required with intermittent operations. This method lends itself to the future expansion of a dust system into existing bag houses. However, installations and equipment costs may be greater, and maintenance is higher because of fan wheel wear.

Fans

Typical dust control equipment includes fans, cyclones, and baghouse filters. There are two styles of fans used in these systems. The basic design difference is in the fan wheel. The backward inclined fan with wheels (BI) must be used in a clean air stream, limiting it to a negative pressure system. It is the more energy efficient fan style, as it will move more cfm of air per hp than does the straight bladed fan. Straight bladed fans with wheels are capable of operating in a dust-laden air stream because of their self-cleaning tendencies. Because these wheels self-clean, they do not (under normal operating conditions) develop an uneven dust build-up on the fan wheel to cause an out-of-balance condition.

Baghouse filters are units in which dust is removed from the air stream by retention in or on a porous fabric filter bag through which the air flows. Fabric filters have the advantage of being a positive collector. That is, the filter media is positioned between the dust laden air and the clean air plenum and forms a barrier to prevent the escape of dust. Because of this arrangement, and with

the proper filter media selection, efficiencies of 99.8% can be achieved.

There are three basic types of filters used in the feed industry.

- *Low pressure, high volume reverse air* cleaning filters are commonly used. Because they clean with low pressure air, internally mounted fans provide all cleaning air needed. There are no compressors, no air lines to freeze in cold weather, and no valves or mechanical flaps to fail. These units are ideal for cleaning where high humidity and freezing conditions are common. They also lend themselves to outside locations.
- *High pressure compressed air*, commonly called Reverse Pulse, filters are also used. The cleaning action of the bags is accomplished by the use of compressed air. The filters have a compressed air header that stores high pressure air until the control panel timer electrically fires (or discharges) one row of bags at a time and cleans each row in the unit on an adjustable time basis.
- *Shaker filters* are designed for low maintenance and are used when no compressed air is available. A rocking arm shaker mechanism accomplishes bag cleaning and can be either

manually operated or motor driven. Snap band bag removal from the tube sheet is quick and easy while assuring a positive bag seal. There are two major disadvantages of the shaker filter. First, it is not a continuous filtering unit, since the air flow must be shut off during the cleaning operation; and second, the air-to-cloth ratio must be held to a maximum of 4:1.

Cyclone Collectors

There are many styles of cyclone collectors. Many are very good collectors, but all are limited to features that affect their efficiency and capability: collector body diameter, air inlet velocity, dust loading, particle size, and particle density. The proper application for a centrifugal collector is one which can be precisely defined and controlled so that performance can be maintained. Examples of this type of system would be pellet coolers, petfood dryers, and other high temperature, high moisture, low dust loading applications. Field test results that indicate high efficiency (no visible emission) from this type system can be obtained from most knowledgeable manufacturers (Table 13-2).

Table 13-2. EFFICIENCY CHART FROM FIELD TEST H. E. COLLECTORS.

MODEL	TYPE PRODUCT	OPTIMUM AIR FLOW	ACTUAL AIR FLOW	OUTLET TEMPERATURE	EMISSION-- GRAINS PER 1000 CU. FT.	MASS EFFICIENCY	EMISSIONS SOURCE	FIELD TEST LOCATION
*** 2H36	Pelleted Cattle Feed	14250 CFM	14111 CFM	86°	.052	99.97%	California Pellet Cooler	Land-O-Lakes Clarence, Iowa
* 2H39	Extruded Petfood 7 TPH	15400 CFM	15484 CFM	152°	.446	99.3%	Wenger Dryer	Tuffy's Perham, Minn.
* 2H43	Extruded Cat Food 6½ TPH	20250 CFM	19957 CFM	154°	.341	93.67%	Wenger Dryer	Tuffy's Perham, Minn.
* 2H47	Extruded Dog Food 7 TPH	23624	13882	204°	.420	83%	Proctor-Schwartz Dryer	Perk Foods K.C. KS.

It is very important to maintain the recommended air flow. This installation was 41% below the optimum air flow causing the much reduced mass efficiency.

It is important to note that none of the above tests had any visible emissions.

MODEL	TYPE PRODUCT	OPTIMUM AIR FLOW	ACTUAL AIR FLOW	OUTLET TEMPERATURE	EMISSION-- lbs./hr.	ALLOWABLE EMISSIONS lbs./hr.	EMISSIONS SOURCE	FIELD TEST LOCATION
** 2H43	Spent Grain Dryer	20250 CFM	15180 CFM	190°	3.385	18.030	Rotary	Midwest Solvents Atchison, KS.
** 2H43	Spent Grain Dryer	20250 CFM	16200 CFM	190°	1.310	18.030	Rotary	Midwest Solvents Atchison, KS.
** 4H47	Spent Grain Dryer	47240 CFM	37620 CFM	190°	3.115	39.760	Rotary	Midwest Solvents Atchison, KS.

* Test Conducted by Dr. Jason Annis, K.S.U.

** Test Conducted by Midwest Solvents under observation of Kansas Air Environmental Health Division

*** Test Conducted by MAC Equipment Engineering Department

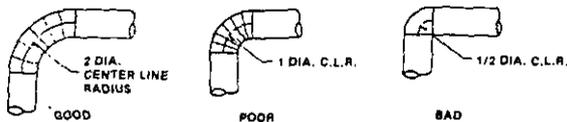
MAC EQUIPMENT, INC., Box 205, Sabetha, Kansas 66534 Tel. 913/284-2191

Duct Design

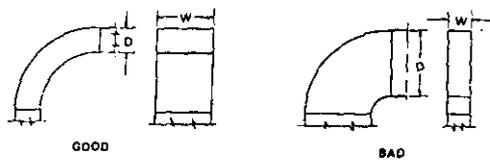
Proper duct design is mandatory to ensure correct ventilation. All ducting should be galvanized and in accordance with the following standards:

Size (in.)	Pipe	Elbows
0 - 8	22 Gauge	20 Gauge
8½ - 15	20 Gauge	18 Gauge
16 - 25	18 Gauge	16 Gauge
25½ - up	16 Gauge	14 Gauge

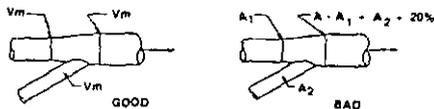
All ducting should have centerline radii on elbows of a minimum of two times the collector diameter (Figures 13-16 and 13-17). Branch fitting should be at 30°, never at 90°. Transitions and hoods should be smooth and clean flowing, not square with abrupt corners.



ELBOW RADIUS
Elbows should be 2 or 2½ diameters centerline radius except where space does not permit.



ASPECT RATIO
Keep AR ($\frac{W}{D}$) high in using rectangular duct



PROPER DUCT SIZE
Vm - Minimum transport velocity.
A - Cross section area.
Size the duct to hold the selected transport velocity or higher.

Fig. 13-16. Proper duct design.

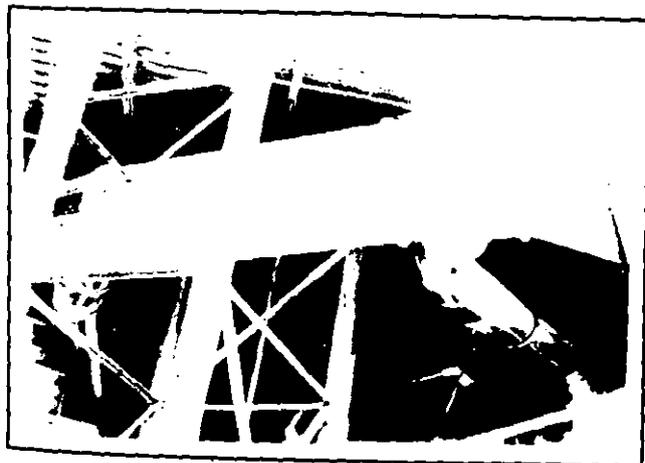


Fig. 13-17. Branch fitting.

Rolled flanges are required in straight ducts and at all elbows and equipment connections. All companion rings and angles should be in accordance with the following standards:

Pipe diameter (in.)	Ring (in.)
0 - 16	$\frac{3}{16} \times 1\frac{1}{4}$
16 - 25	$1\frac{1}{4} \times 1\frac{1}{4} \times \frac{1}{8}$
25½ and up	$1\frac{1}{2} \times 1\frac{1}{2} \times \frac{3}{16}$

Blast gates for adjusting the system should be provided for all dust pickup points and located for easy access and in horizontal duct runs where possible.

Cleanout and/or inspection doors are sometimes desirable. If they are used, they should be located at the top of the duct with the least obstruction of air flow possible.

All ducting should be securely fastened in place, sufficient to prevent placing any load on connecting equipment and to carry the weight of the ducts.

Knowing these operational problems could save the operator from some of these troubles: (1) Plugging of the dust return spout that causes dust to build up through the airlock and into the filter, usually causing the airlock motor to overload and kick off and, if allowed to continue, will actually fill the complete filter housing with dust. The reason is too flat an angle on the spout. To avoid this, the dust return spout from the filter should be installed at a minimum of 70° (Figure 13-18); (2) Failure of motors on start-up, undersized wiring, improper size starters, and improper sized heater coils can cause electrical problems. Furthermore, it is recommended that a time delay relay be used in a system to allow the filter cleaning mechanism and airlock to run approximately 5 minutes after the main exhaust fan is shut off; and (3) Ineffective hoods, including those that do not fit properly or have square corners on ducting and branch fittings coming in at 90° angles, will all create an air turbulence that causes dust to settle and buildup in the duct.

Many feed plants have a pellet cooler or roller mill cooler

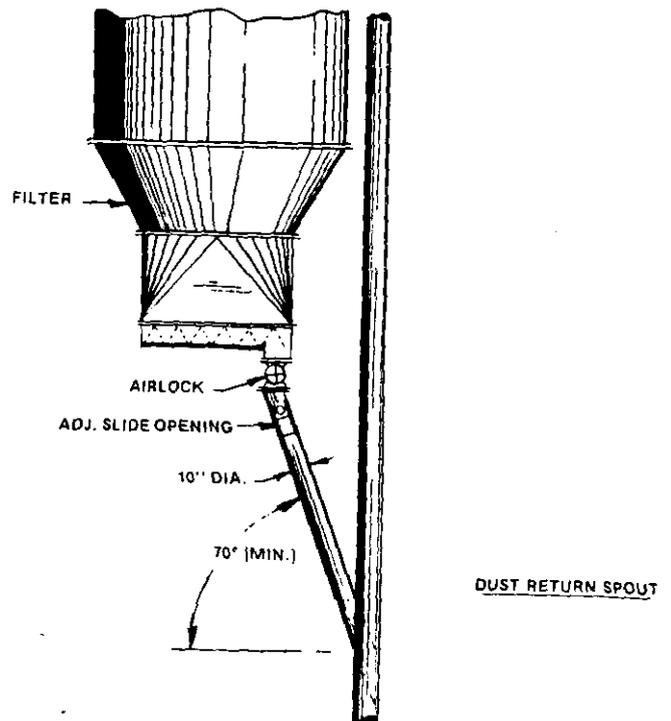


Fig. 13-18. Dust return spout.

system. Products conveyed in these types of systems release moisture. In fact, if a collector is being used on the pellet cooler, an average of 14 to 17% moisture will be released from the exhaust and a baghouse filter would be inefficient. However, when properly applied, a dust collector such as the MAC Hi-Efficiency Collector will eliminate all visible particulate emissions and meet EPA standards.

When choosing a collector, the most important point to remember is that the fan and collector must be in balance with one another. Therefore, it is wise to purchase the collector and fan from a common manufacturer. The manufacturer will recommend a flow rate desirable for his equipment in combination with the customer's needs. Simply following the manufacturer's recommendations will help to avoid problems.

As previously mentioned, a filter or collector must be installed enabling the discharge tailing spout to be straight or at a minimum of a 70° angle. Also, as a consequence of moisture release, many collectors operating in cold climates are insulated.

A negative system for pellet coolers is highly desirable because product does not pass through the fan. When a product is passed through a fan, the fan tends to break down the particle size. This is a disadvantage because the smaller the particle size, the more difficult it is to collect the dust.

Particle size, density, particle loading, diameter of the collector, and inlet velocity are the crucial factors affecting the performance of any centrifugal dust collector. The higher the inlet velocity, the greater the centrifugal force acting on the dust particles and the greater the separating efficiency.

SYSTEM DESIGN

Once a system is designed, it is important to hire a qualified contractor to install it. There have been many inadequate systems installed due to poor system design and misapplied equipment. Therefore, it is imperative that the dust system be designed and installed properly. The installation of a poorly designed pneumatic dust control system fosters a false sense of security and has often led to inappropriate reduction in scheduled housekeeping.

System design is of utmost importance, as the effectiveness of the system in concept, control, maintenance, and operation must all be considered. The following steps are to be followed for a systematic concept in design:

- *Determine the dust emitting points.* A plant survey and close observation of existing equipment will expose the dust emitting points in the system.
- *Determine the volume of air to be pulled.* To determine the amount of air that is required to be pulled by the system, information must be collected during the plant survey, such as pit sizes, belt widths, leg capacities, mixer sizes, hammer-mill types and sizes, screen types and sizes, bagging equipment, etc. Next, determine the amount of air to be pulled from each pickup point.
- *Draw a schematic diagram of the system.* The sketch should indicate all pickup points, approximate lengths of runs, and equipment needed. It is simply a worksheet to keep all information tabulated and recorded.
- *Determine the size and type of collector.* Determine the type of filter or collector and the air-to-cloth ratio to be used.

- *Calculate the static loss in the duct system.* Calculate total system static pressure (sp). To calculate the static loss in the system duct work, the designer must have the duct runs planned for physical routing. This should be done during the plant survey as much as possible. List the lengths of straight runs and the number of elbows. Also, determine the size of ducting. Then, total the static pressure losses from all ducting, cyclones, or filters and determine the total system static pressure.

- *Select a fan.* With these data, the designer can select the proper size of fan and the horsepower required to operate it.

A dust control system can be effective and relatively trouble free if properly designed, installed, operated, and maintained. When designing a dust control system, always recommend the following:

- Transport velocity of 4000 ft/min, minimum.
- Maximum of 10:1 air-to-cloth ratio with 9:1 maximum on the Gulf Coast.
- A determination of how the dust is going to be handled. It can be returned to the stock handling system or put in a dust storage tank. If it is going to be returned to the stock handling system, it should be returned downstream from the pickup point. Steps must be taken to assure that, when it is returned, it is blended in to become part of the product flow. Do not attempt to return dust to a turbulent area such as the elevator leg casing as it is unsatisfactory to put dust immediately into suspension after returning it to the system.
- Install the system as it was designed. Not only should it be installed as it was designed, but the system must be properly balanced after installation is complete.
- No visible emission. Design for no visible emission from pickup hoods and enclosed equipment.
- Capture velocities of 200 ft/min minimum at all points of a hood.
- No floor sweepings into the dust control system.
- Proper installation of monitoring devices. Systems should have a static pressure gauge, a level indicator to signal dust build up, a shut off alarm on the airlock, and a proper interlock to provide correct start-up and shut-down cycles.
- Acceptance and performance test. When installing a new dust control system, include as part of the system design and proposal an acceptance test that includes, after 30 (or 45) days operation, minimum cfm, transport velocities, and maximum static pressure readings.

When a bag filter is first put into operation, the differential pressure drop across the filter is very low; however, it tends to build up with time, which is the reason for the lapse of 30 to 45 days before inspection. If the system is undersized or misapplied, the problem will show up after a period of operation indicating a high differential pressure and reduced air flow.

In summary, this synopsis of dust control in the feed industry has attempted to take one point at a time for examination thereby enabling the reader to compare his own operation to our recommendations. Recommended flow rates and points of aspiration as well as problem points were stressed. The reader hopefully has gained a better understanding of dust control and the reasons for concern.

Air Pollution Control

Glenn J. Boresi
Ralston Purina Company

Industry has a responsibility to assist in maintaining environmental conditions at a level that will assure the health and welfare of man, animal, and vegetation. To fulfill this responsibility, the complex ecological cycle of nature must be preserved. Great strides toward achieving this have been made as a result of government's legislative initiative and industry's technological cooperation.

One problem, which is constantly being improved, is air pollution. In feed manufacturing, the primary air pollutant is particulate matter, i.e., dust, while the secondary pollutant is sulfur dioxide. The handling of grain, starting with receiving and ending with shipping, generates particulates. Generation of particulates can, in certain circumstances and under certain conditions, have deleterious effects including, but not limited to, the following:

- Precursor to dust explosions in confined areas.
- Toxic to man and animals via the respiratory system as a result of physical interference with respiratory passages.
- Aggravates symptoms of individuals suffering from respiratory diseases.
- Obscures visibility.
- Corrosive depending on the particulate's chemical characteristics.

Sulfur dioxide is generated in the fuel combustion process used to produce steam. Due to the low amount of steam required, sulfur dioxide emissions from feed plants are not usually a major concern; however, they should not be dismissed. Some of the effects of sulfur dioxide in the atmosphere remain the subject of intense debate; these effects can, under certain conditions and circumstances:

- Constrict respiratory passages that aggravate the symptoms of individuals suffering from heart and lung disease.
- Be toxic to plants' foliage.
- Corrode textiles, building materials, paints, and metal.
- Be a precursor to acid rain.
- Obscure visibility.

Because of these effects, the potential impact on the environment must be fully appreciated, particularly since acceptable sulfur dioxide emission rates can usually be achieved by using low sulfur content fuels.

The remainder of this chapter discusses how pollutants are generated in feed manufacturing, how they are typically controlled, and the framework of air pollution control legislation. It is important to keep in mind that it is the air pollution regulations that ultimately determine the required level of control. It is equally important to realize that air pollution regulations are constantly being updated and that they have built-in flexibility in certain cases.

GENERATION OF POLLUTANTS

Particulate matter, i.e., dust, is generated when ingredients or finished products are flowing in mass with or without the assistance of mechanical systems. The amount of dust generated is

a function of the material's characteristics including moisture content, density, texture, and component configuration; and the processing equipment's operating characteristics including agitation, processing rate, air flow rate, material conveyance method, and moisture control.

Since many factors affect dust generation and an awareness of the mechanics involved is necessary to minimize its incidence, the phases of material handling and the manufacturing process must be analyzed separately. Feed manufacturing and material handling operations have been discussed in Sections III and IV; therefore, this chapter concentrates on the mechanics of dust generation by specific operation.

Bulk Material Receiving

Ingredients are shipped to feed manufacturing plants by rail cars and trucks. The type of truck or rail car determines the type of unloading system that is used.

Railroad hopper cars, hopper-bottom trucks, trailers, and dump trucks are self-unloaded by gravity flow into subgrade unloading hoppers. Mass flow rates from these transporters can be regulated to accommodate the capacity of the unloading pit. Several self-unloading, gravity flow systems are available because different systems are required for different transporter types. Figures 53-1 and 53-2 illustrate hopper bottom and truck dump unloading systems.

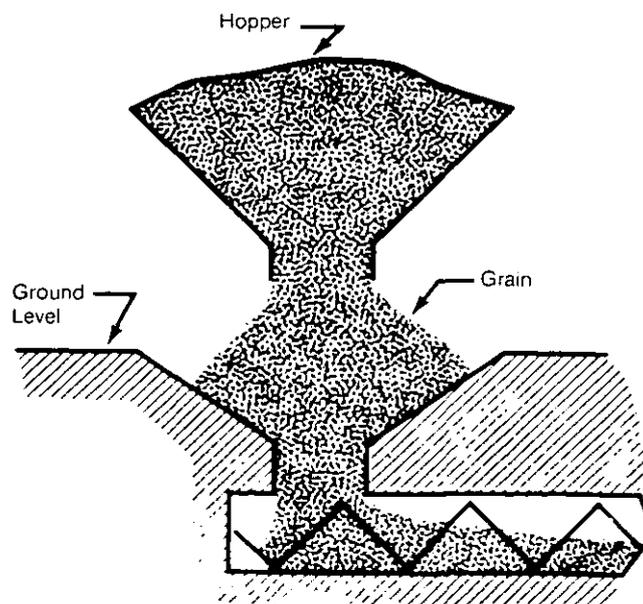


Figure 53-1. Hopper bottom unloading system.

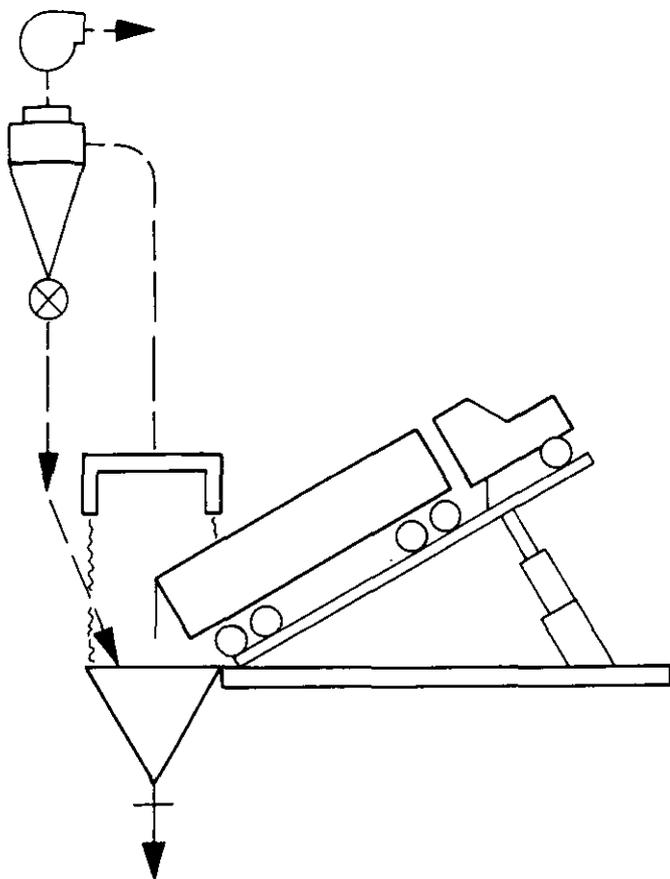


Figure 53-2. Truck dump unloading system.

The construction of the unloading pit, type of transporter, material free-fall distance, unloading rate, material characteristics, and ambient conditions are all significant factors contributing to dust generation. Of these six factors, the material characteristics and type of transporter are frequently not controllable by the feed manufacturer.

Hopper bottom unloading allows greater control over dust generation than truck dumping, as mass flow and free-fall distance can be more strictly regulated. Deep unloading pits used in truck dumping operations to allow for material surge are not necessary for hopper bottom unloading operations because greater mass flow control can be exercised.

In truck dumping operations, the angle of inclination and interparticle friction govern mass flow. Consequently, the operator cannot effectively control the surging flow. Conversely, in hopper bottom unloading, mass flow can be accurately regulated by using shallow unloading pits and screw conveyors, as shown in Figure 53-1. This application, termed the choke-feed method, eliminates material free-fall and surging mass flow rates. Since the feed manufacturer cannot completely control the type of railcar or truck supplying the plant, both types of transporters must be serviced; however, the choke-feed method minimizes dust generation.

Boxcars emptied by front-end loaders or power shovels constitute another type of unloading system. As in truck dumping operations, the material is allowed to free-fall from the transporter into the unloading pit, thereby producing a dust cloud. Besides generating dust, this system consumes inordinate manpower. Therefore, if possible, ingredient suppliers should be required to employ self-unloading transporters.

Occasionally, ingredients are transported from the rail cars and trucks by pneumatic conveyors. The material is usually blown through a cyclone receiver, which separates the materials from the air. The air is discharged to the atmosphere and the material to a storage bin. Infrequently, the material is expelled directly into a storage bin and the excess air emitted through a bin vent filter. A vent is required on the storage bin to relieve air displaced by the entering materials.

Bulk Material Conveyance

Bulk material is conveyed to storage and processing equipment by conveying mechanisms that include screw conveyors, belt conveyors, pneumatic conveyors, oscillating conveyors, drag conveyors, bucket elevators, and gravity flow. The type of conveyor, its application, and the operating procedure all greatly affect dust generation.

Screw conveyors are among the oldest and simplest methods used to move bulk materials. A screw conveyor consists of a rotary screw mounted inside a conveying trough. For each rotation of the screw the material is channeled along the trough by the spiralled flange. A screw conveyor can transport bulk material horizontally or at inclines of 90 degrees. Screw conveyors are easily covered making them dust tight; however, allowance for air displacement must be made. The displaced air should be discharged to an air pollution control device to recover valuable product and to protect the environment. Screw conveyors are an excellent and simple method of controlling dust.

Belt conveyors are widely used to transport bulk materials due to their simple and inexpensive operating characteristics. They can be troughed or flat, but are not as adaptable to inclined conveyance as screw conveyors. Also, they are not as easily enclosed as screw conveyors, which results in dustier operations. Therefore, in dust sensitive areas, it is advisable to use screw conveyors. Also, screw conveyors are more compact than belt conveyors. This characteristic is very important in space limited areas. Thus, belt conveyors can be successfully applied when the material is relatively dust-free and space is not a major factor.

Pneumatic conveyors were originally used to control dust. Some advantages of pneumatic conveying include ease of installation, layout flexibility, multiple feed and discharge points, low maintenance requirements, self-cleaning capability, and dust control. Some disadvantages include high operational cost compared to mechanical systems, high initial costs that can exceed capital expenditures for a mechanical system, and limited material applicability.

Since pneumatic conveyors operate by blowing or sucking material through a pipe, dust containment is an inherent property of the system. Dust is generated but is conveyed along with the material. Due to the relative weight of the dust compared to the material, the dust remains suspended in the air when the material is discharged. However, the suspended particles are easily directed to an air pollution device to separate them from the air. The air is discharged to the atmosphere and the dust is returned to the process. Although pneumatic conveyors are environmentally desirable, operating costs may be prohibitive.

Oscillating conveyors move material by the forward and upward repetitive motion of a trough. They can handle a wide variety of material, can easily be made dust tight, and are relatively compact. By varying the oscillating speed, dust generation can be minimized. Their major disadvantage is that a single drive is effective for a maximum length of only 100 feet.

Oscillating conveyors, properly operated, can keep dust concentrations to a minimum; however, for long transitions they

are not cost competitive with screw and belt conveyors. Also, oscillating conveyors are more operation and maintenance intensive than most of the other systems.

Drag conveyors can be used in many of the same applications as screw conveyors. However, drag conveyors move material more gently and are relatively self-cleaning. A drag conveyor consists of a series of paddles mounted on a drive chain that revolves within a stationary trough. The trough is easily covered to make it dust tight. Drag conveyors are more effective in moving material up an incline than screw conveyors; however, an allowance should be made for displaced air. Application of an air pollution control device to the displaced air is necessary to recover product and minimize dust emissions. Although operating costs for drag and screw conveyors are comparable, drag conveyors are usually a more expensive capital and maintenance cost item.

Bucket elevators are used to move material vertically or up steep inclines. They consist of a series of buckets attached to a drive chain or belt that revolves within a casing. Material is fed into the bottom and discharged at the top, and the buckets are empty on the downward return. Due to the rotary motion of the system, air currents develop within the casing and generate dust. If the bucket elevator is operated at too great a speed, spillage and dusting can become intolerable. As with all conveyors, an air pollution control device is recommended to recover product and minimize dust emissions.

Gravity flow of material requires enclosures such as spouts or chutes. The angle of inclination and the spouting arrangement (angles, elbows, etc.) determines how much dust will be generated. However, dust can be controlled by applying dust tight enclosures and air pollution control devices.

All conveyors require dust control, including enclosures and air pollution abatement devices, to recover product and minimize dust emissions. The entire conveyance system should be analyzed to optimize the centralization of the air pollution control device(s). Not every conveyor requires an air pick-up to transfer the dust to the control device. These pick-ups are selected by establishing key areas (e.g., transfer and discharge points) and determining their ventilation requirements. Refer to Section III, Chapter 13, for a discussion of dust collection systems for materials handling and storage.

Manufacturing Operations

After ingredients are received, several operations are employed. These include ingredient processing, proportioning and mixing, pelleting, extruding or blocking, and possibly, packaging.

Ingredient processing includes grain cleaning and grinding. Grain cleaning removes dockage that includes dust, dirt, stalks, sticks, stones, stems, and other grains mixed with the bulk ingredient. Cleaning is a three-step operation. The first step is scalping, which employs a coarse mesh screen supported within a dust tight enclosure. The whole unit either shakes or revolves. Since the velocity of the grain through the screen is low, the enclosure is dust tight and there is no aspiration; therefore, dust control is not required. The second step is aspiration, which employs air streams directed perpendicular to dispersed, falling grain. The aspirator removes field dust, chaff, and light trash. Due to the nature of the unit's operation, large amounts of dust may be generated. The air discharged from the aspirator must be cleansed before being discharged to the atmosphere. Sieving is the final step in the grain cleaning process. The sieve is designed to remove mixed grains and weeds. It consists of a series of different sized, meshed screens supported within a dust tight enclosure requiring no air pollution control.

Many feed plants use hammermills to grind ingredients. These units accomplish both grinding and air conveyance. Grain is fed into the center of a high-speed rotor where the pivoted hammers move it to the perimeter screen. The grain is forced through the screen, usually with the aid of supplemental air. The ground product is pneumatically conveyed to a cyclone separator or filter receiver that separates the air from the ground ingredient. It can also be moved using mechanical conveyors and bucket elevators.

In proportioning and mixing, ingredients are conveyed from storage bins to a hopper scale that weighs the batch and feeds it to a mixer. Dust is generated when the ingredients are dumped into the hopper scale, which should have a vent fitted with a filter to relieve the displaced air and minimize dust emissions. No other dust control is required.

Pelleting, extruding, and blocking are methods of producing moist agglomerated particles with little or no dust emissions. However, following pelleting and extruding, cooling or drying is required, utilizing large air flow rates. Although the dust generated in these operations is not great, its control is necessary to prevent product loss. Cyclone collectors are typically used to prevent such loss.

The pelleted or extruded product passes through a shaker to achieve particle separation before packaging, bulk storage, or bulk shipping. Some dust may be generated during this operation depending on product moisture; therefore, a dust tight enclosure is required to prevent product loss.

Bulk Product Shipping

The bulk loading of rail cars or trucks is similar to bulk storage operations; however, the amount of dust generated may be much less due to liquid additions and product forming. Downspouts feed the product into the rail car or truck; however, due to the free-fall and impact of the product inside the compartment, a dust plume may be generated. Dust control methods include spout jackets, area enclosure and hooding, and ventilation to air pollution control equipment.

Loading of bulk feed into rail cars and trucks can also be accomplished pneumatically. If pneumatic conveyors are used, a filter cloth screen should be applied to the opening to contain the dust.

Boilers

The incomplete combustion of fuel for steam generation releases particulates, sulfur oxides, nitrogen oxides, carbon monoxide, and hydrocarbons to the atmosphere. Particulates and sulfur dioxide are of primary concern. The percentages of ash and sulfur in the fuel are directly proportional to the emission of particulates and sulfur dioxide. Emission levels can be controlled by fuel selection. Natural gas and No. 2 fuel oil are relatively clean burning and usually require no air pollution equipment. Coal and Nos. 5 and 6 fuel oils are dirtier fuels and occasionally require air pollution control equipment to clean the flue gas.

The decision and capability to burn a certain fuel type depends on the relative price of different types of fuel, the capital and operating cost of air pollution control equipment, the USEPA designation of the plant's geographical location, and the applicable regulations. Due to fluctuating fuel prices and low levels of fuel consumption, it is usually advisable for small users to burn the cleaner fuels.

CONTROL OF POLLUTANTS

Excluding boilers, the control of air pollutants at a plant is limited to dust control. Suitable dust control can be achieved by adopting strict operating standards and utilizing air pollution control equipment. This equipment can usually be limited to simple inertial separators and filters while operating standards relating to air pollution control are based on containing and minimizing dust generation.

Cyclone Separators

Cyclone separators are the most commonly used air pollution control devices in feed manufacturing. There are many different types of cyclone separators; however, feed plants usually employ simple, low, medium, and high efficiency cyclones. High efficiency, multiple cyclones and wet cyclones have higher operating costs and are more prone to maintenance problems.

Cyclones employ inertial separation as the removal mechanism. Centrifugal force separates the particulates from the air. The dirty gas is forced to rotate within the cyclone. The heavier particles impact the cyclone wall and fall to the bottom of the unit while the gas reverses its downward spiral and exits at the top of the unit as shown in Figure 53-3. Cyclone separators are used to remove particles 10 to 20 microns in size and larger. The efficiency of cyclones in plant applications ranges from 80 to 95 percent depending on the dust stream and the type of cyclone employed. High volume, low efficiency cyclones are sometimes used as precleaners before the gas passes on to another piece of air pollution control equipment.

Cyclone applications in feed mills include pneumatic con-

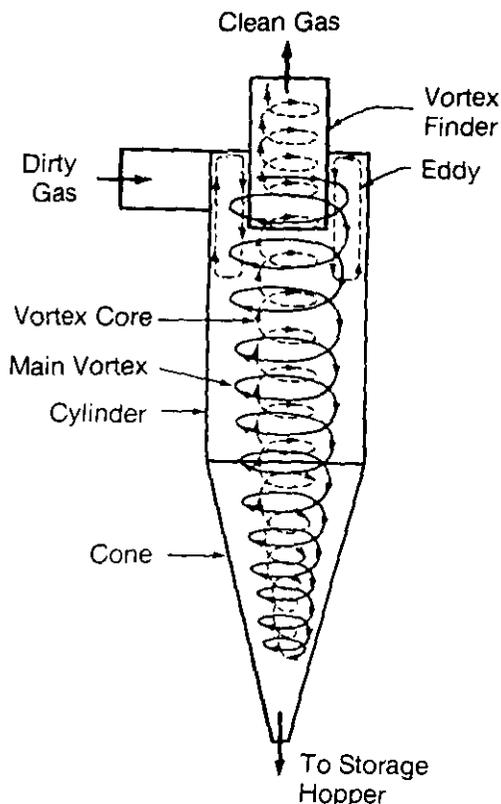


Figure 53-3. Typical cyclone separator.

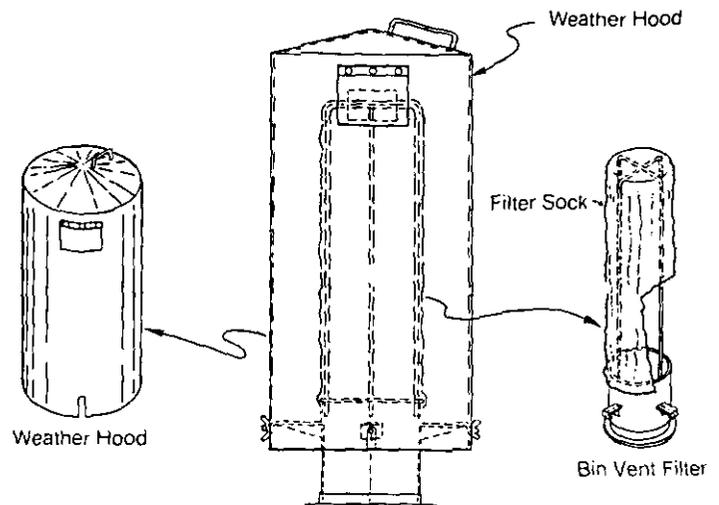


Figure 53-4. Typical bin vent filter.

veyors, storage bins, ventilating hoods, receiving systems, and processing units. Cyclones can be used almost exclusively in rural areas; however, in more congested or air pollution sensitive areas, more efficient air pollution equipment (i.e., fabric filters) may be required.

Vent Filters

Vents, necessary for relieving displaced air, require dust control to retain product and ingredients and to minimize dust emissions. Storage bins without dust control can emit dust plumes that can completely obstruct visibility. Dust plumes emitted from storage bins and surge hoppers can be effectively controlled by fitting the vent with a filter consisting of a cloth sock or bag securely fastened to the vent. Cotton sateen is a common filter cloth material. If the bin vent filter is exposed to the elements, a metal enclosure is required to protect it. Figure 53-4 illustrates a typical vent filter, which is usually 1 to 3 feet in diameter and 2 to 5 feet in height.

Typical design loadings for vent filters range from 4 to 6 cubic feet per minute per square foot of cloth area. A dust cake should not be permitted to accumulate on the cloth as it encourages insect infestation and reduces the filter's efficiency.

Spout loading of trucks and rail cars is a second application for vent filters. As bulk product is discharged into a rail car or truck, dust escapes through the loading portals. To contain the dust, a vent filter skirt can be secured (wrapped) around both the spout and the opening. A third application of vent filters is on pneumatic systems consisting of a filter cloth screen fitted on boxcars, hatchways, and loading portals to retain dust materials.

Baghouses

Baghouses are used in lieu of cyclones when a greater removal efficiency is required. Baghouses or fabric filters can achieve removal efficiencies of 95 to 99.9 percent; however, they are more operation and maintenance intensive than cyclones. Also, for some applications, baghouses require precleaning of the dirty air stream, which is usually accomplished by using a cyclone.

Generally, dirty gas enters the bag at the bottom of the baghouse and exits through the individual bags leaving the dust

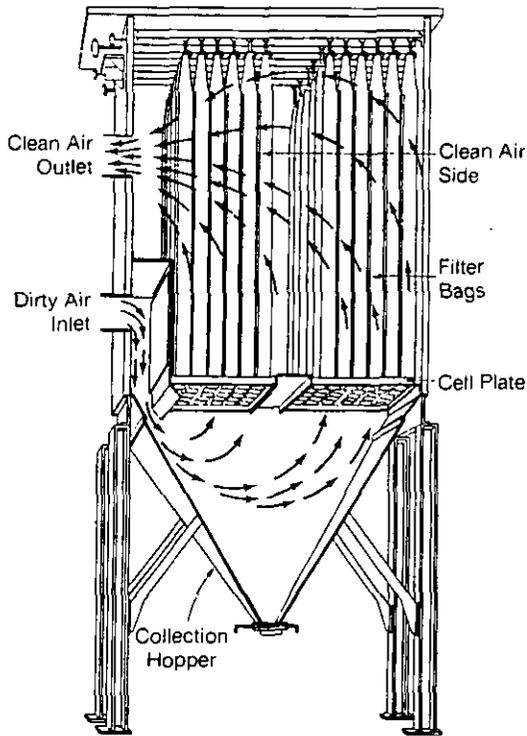


Figure 53-5. Typical bag house unit.

deposited on the interior. Figure 53-5 illustrates a typical baghouse. Baghouses are available in a variety of designs that are classified by the method of cleaning and whether the cleaning operation is intermittent or continuous.

There are many methods of cleaning; but, basically, bags are either flexed, backflushed with air, or a combination of both. The cleaning cycle is necessitated by the deposition of particulate matter that forms a dust cake. The dust cake must be removed or it will reduce, and eventually stop, the flow of gas through the filter. When the bags are cleaned, the dust falls to the bottom of the unit where it is collected and transported away. The bags can be cleaned all at once (intermittent operation) or a few at a time (continuous operation). In continuous operations, a modular design is recommended to keep the falling dust from being re-entrapped in the dirty air stream.

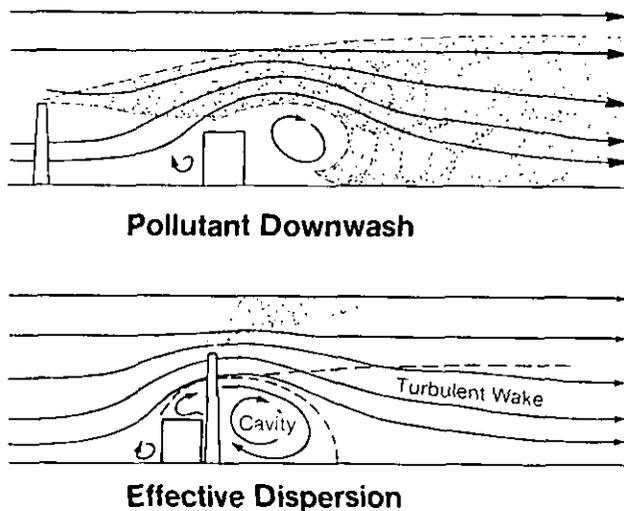


Figure 53-6. Building location effects upon dispersion.

Other Air Pollution Control Techniques

Dust may be controlled, in part, by the method in which materials are handled. These techniques are varied, but are all important in minimizing dust emissions. The techniques include stack height and location, method of bulk unloading, method of bulk loadout, hooding, enclosure, internal venting, and housekeeping.

Stack discharge height and location affect the dispersion of the air pollutants. If a discharge stack or vent is not located at a high enough elevation, air currents over nearby structures could cause downwashing as shown in Figure 53-6. For low emission rates, downwashing is not an important consideration.

In bulk unloading operations, the design of the unloading system can greatly impact dust emissions. The choke feed method of unloading is highly desirable in minimizing dust generation. Also, unloading by pneumatic conveyance allows for dust containment. However, deep unloading pits are undesirable due to the amount of dust generated; but economic conditions may require their use.

To control dust with such a pit, two measures should be implemented. First, air should be exhausted below the grate to air pollution control equipment; baffling should be used below the grating to reduce the area open to the atmosphere and the air capacity required for adequate venting. Figure 53-7 illustrates the design of a hood for a deep receiving hopper. The second measure entails complete enclosure of the receiving area during the unloading operation. Enclosure isolates the receiving area from wind

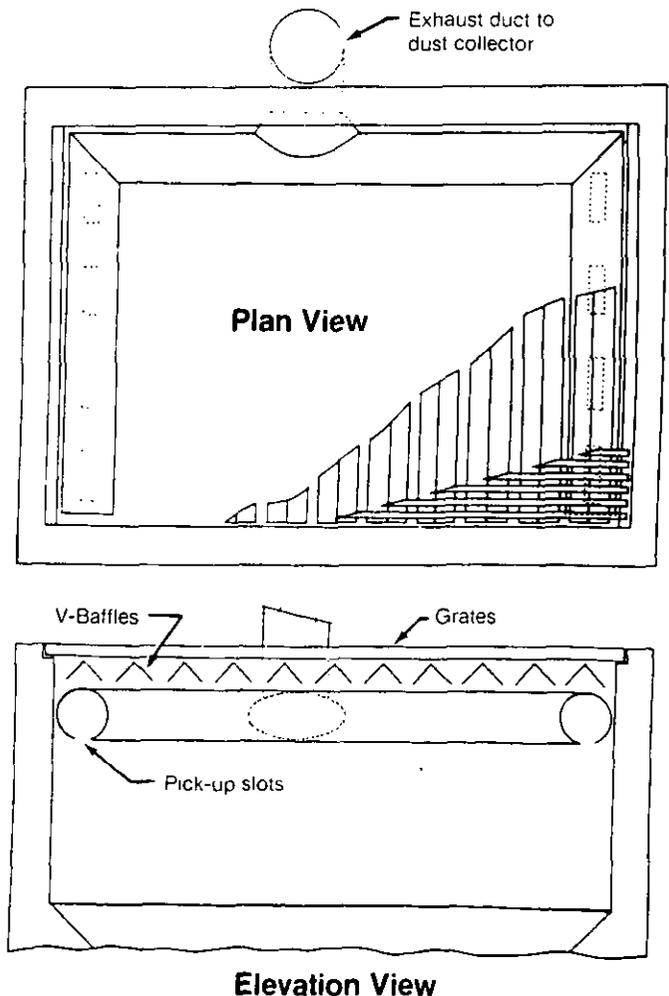


Figure 53-7. Hood design for a deep receiving hopper.

currents, thereby allowing effective operation of the deep hopper venting system.

In sensitive air pollution areas, internal venting of cyclones and fabric filters may be warranted. However, the affected internal area should not be frequented by employees, and precautions should be observed to prevent dust explosions (e.g., National Electric Code).

An important practice in minimizing dust is housekeeping, which includes regular cleanup of settled dust and spilled grain in all areas. Neglecting this practice can contribute to a violation of federal, state, or local regulations depending on meteorological conditions. Poor housekeeping can negate an otherwise good air pollution control program.

The above air pollution control techniques are only a few of the many measures that can minimize dust concentrations. It is important to carefully review all designs to ascertain their potential affect on dust generation. The degree of enclosure, hooding, ventilation rate, conveyance method, and material agitation are a few things to consider when reviewing any design.

REGULATIONS

Air pollution regulations in the United States are embodied in a very complex and changing piece of legislation termed the Clean Air Act. The purpose of the Clean Air Act is to realize the national commitment to protect and enhance the nation's air quality. To attain this goal, the National Ambient Air Quality Standards (NAAQS), various national emission standards, and a state and local regulatory framework have been established. Emissions from feed plants do not normally include those pollutants covered by national performance standards, except in certain new or upgraded facilities. Therefore, the following discussion will be limited to the legislation promulgated to attain the NAAQS.

The NAAQS were designated for specified pollutants, including particulate and sulfur dioxide, to fulfill two criteria: (1) the protection of human health with an adequate margin of safety; and (2) the protection of public welfare, which includes wildlife, plants, climate, and recreation. To attain or preserve the NAAQS, the following key programs were adopted under authority of the Clean Air Act:

- State Implementation Plans (SIP).
- Prevention of Significant Deterioration (PSD) Program.
- Nonattainment Program.

State implementation plans outline the programs to be used to attain the NAAQS within each state. They incorporate both state and local air pollution regulations and make them federally enforceable.

The purpose of the PSD program is to preserve air quality in areas that are in compliance with the NAAQS. These areas are called "attainment" or "PSD" areas. They have been sub-categorized into Class I, II, and III regions. Class I regions are pristine areas with extremely stringent permitting requirements, such as national parks. Most PSD areas are Class II and have less stringent permitting requirements. Class III areas can afford a large increment of deterioration before NAAQS are violated. To preserve air quality, no Class III areas have been designated.

The PSD program requires a preconstruction review of all projects affecting air quality. If the increase in the mass emission

rate of a criteria pollutant is large enough to define the project as a new major source, application of best available control technology (BACT) and an extensive permit review process is required. New minor sources may or may not require air pollution control. Permitting procedures are much less stringent.

The USEPA has identified certain industries and promulgated special regulations applicable to them entitled New Source Performance Standards (NSPS). Grain elevators are included under the NSPS; however, the definition of a grain elevator usually excludes feed plants. Affected facilities and their new construction must apply the best demonstrated technology (BDT) for air pollution abatement. BDT takes into account air pollution control costs, unlike BACT. The NSPS also establishes minimum criteria for BACT. The NSPS has its own separate body of regulations; however, for the purposes of this text, it has been discussed under the PSD program to facilitate a simple understanding of complex regulations.

The purpose of the nonattainment program is to achieve compliance with the NAAQS within a specified period of time in those areas that exceed the standards for any of the criteria pollutants. However, it must be understood that attainment and non-attainment status are pollutant specific. That is, an area could be designated as attainment for one pollutant and as nonattainment for another.

Nonattainment regulations are applied to existing sources through control strategies or equipment. The application of control technology to existing sources is defined as reasonably available control technology (RACT). An example of a control strategy is a vehicle inspection and maintenance program. Nonattainment regulations are applied to new major sources in the form of emission offsets and a control technology designated as the lowest achievable emission rate (LAER). Offsets are the mandatory net reduction of emissions within the affected area for every institution of a new major source. LAER technology for major sources requires compliance with the most stringent emission standard established by the state or attainment of the most stringent emission level achieved by a source in the same category, whichever is more stringent. A minor source must comply with the emission standards established for the facility's location and industrial category.

Due to its complexity and the periodic modifications to the Clean Air Act, a more detailed analysis will not be pursued. The preceding was presented to provide a basic understanding of the Act's structure. To comply with this legislation and its accompanying regulations, the feed manufacturer should refer to the applicable state's air pollution regulations and seek the advice of an environmental specialist or the state's air pollution control agency. These organizations can advise on the specific regulations, their flexibility (e.g., bubble policy) and possible cost saving mechanisms (e.g., emission reduction credits).

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