Publication 1442 (Section 4)

SWINE PRODUCTION

▪ BUILDINGS AND EQUIPMENT

CANADA DEPARTMENT OF AGRICULTURE

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Prepared under Direction of the Saskatchewan Advisory Council on Animal Production

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NOTE TO READERS

The attention of readers is drawn to the fact that the text for this publication was prepared by the Saskatchewan Advisory Committee on Swine Production and that where recommendations for pesticide use appear, they are consistent with those of that province. However, readers who reside in other provinces should check with provincial authorities to determine whether or not the recommendations apply in their province.

CONTENTS

BUILDINGS AND EQUIPMENT FOR SWINE PRODUCTION

The manual labor associated with swine production can be substantially reduced by careful planning, designing and/or selection of buildings and equipment. The combined cost of housing and equipment constitutes only a small charge to the cost of producing a market hog. The significance of these combined costs is not reflected in the percentage figure, since ease and efficiency of the operation are factors difficult to measure in monetary terms but nevertheless important to the operator. Also, efficient utilization of buildings and equipment combined with good management will reduce other production costs.

The choice of buildings and equipment is the responsibility of the manager. Factors that must be considered during the initial planning phase include:

- What production system will be used?
- What management system will be used?
- How many hogs will be produced?
- What buildings are required and where will they be located?
- How will the environment be controlled?
- How will feed be stored, processed and handled?
- How will manure be handled?

Site

The site selected for the buildings should be well drained and oriented to minimize nuisance odors to dwellings that may be in the area. An adequate source of water is essential. Any statutory restrictions or other municipal regulations regarding the location of the swine enterprise or disposal of manure should be investigated.

Swine housing systems

The selection and layout of swine buildings will be determined by the production system. Depending on the system selected, well-designed facilities are needed for farrowing, growing and finishing, and for housing breeding stock. These sections may be separate or combined in one building. If combined, provision should be made for isolation of each section for disease control. Room for expansion should also be considered. Floor layouts and construction plans are available from the Canadian Farm Building Plan Service as well as other sources through the provincial extension offices.

Structural requirements of a hog barn

Modern hog barns may be built of wood frame construction or a combination of wood and metal. Cold Canadian winters call for very well insulated buildings, and wood frame construction with 4 to 6 inches of insulation is most popular. Use clear-span trussed roof rafters (24- to 36-foot span) for easier remodeling if it becomes necessary.

Most wood frame hog barns are built with plywood on the inside of 2" X 4" or 2" X 6" framing and sheet metal or plywood on the outside. Insulation and vapor

Figure 1. A modern hog barn.

barrier are used as outlined in the section on heating and ventilation. Where pen arrangement allows hogs to come in contact with outside walls, the plywood sheeting should be covered with galvanized steel or asbestos board to a height of at least 3 feet.

Before any concrete is poured, the manure system should be planned, because the manure handling system determines floor, gutter and alley arrangement and slopes.

For a farrow-to-finish operation, the producer must decide whether to have all the enterprise in one building or in separate buildings. The trend is to house all operations in one building for the operator's convenience, but this requires more careful planning of disease barriers between age-groups of the pig herd. T-shaped buildings are popular as they can be expanded without upsetting the balance. For a farrowing barn, the most practical width is 24–28 feet. For a finishing barn, 32–36 feet is more suitable.

Farrowing systems

Several farrowing schedules and systems are being used: one of the most popular is a 2-month farrowing schedule. With this system, about a third of the sow herd is farrowed in a group at 2-month intervals. This allows young pigs to be weaned at 6 weeks, sows can be in the crate a few days before farrowing, and there is a week or so to clean up the farrowing quarters before the next batch.

Another system being used is the monthly schedule. This requires weaning at 3 weeks, but does not allow much time for clean-up. This system requires superior management, but will enable the operator to have a larger number of farrowings per year from a herd of sows and hence should produce a greater number of pigs. These two systems use either crates or pens for farrowing.

Figure 2. Farrowing crates.

There is a trend to another system that uses a combination of crates and pens. The operator divides his sows into six groups and farrows one group every month in crates. After 3 weeks, he moves the sow and litter to pens for another 3 weeks before weaning. The next group of sows enters the crates after clean-up, or about 4 weeks after the first batch. This suits the operator who does not like to keep sows for 6 weeks in a crate, and yet he can practice 6-week weaning.

Growing and finishing systems

Hogs spend 4 to 5 months in a growing and finishing barn or section. Pens are usually made in two or more sizes for growing and finishing. The Canadian Farm Building Plan Service recommends a 6' X 9' pen for 20 weanlings. When the pigs are about 2 months of age, they are moved to a larger pen, 5' X 16', to grow until they are 4 months old and weigh approximately 100 pounds. At this stage, they are moved to two 5' X 16' finishing pens, each of which can handle 10 pigs to market weight.

Pen partitions

Solid pen partitions of planks or plywood interfere with air circulation and ventilation and for this reason are not recommended. Instead, a compromise, using solid cross-partitions (for isolation) and open front gates (for ventilation), is recommended.

Wooden partitions with spaces between planks or boards are chewed by the swine and do not last very long. Also, because they are difficult to disinfect and clean,

Figure 3. Interior of a finishing barn.

disease control is more difficult. The best pen partitions are made of steel. These can be either factory made or made at home. Homemade partitions using 1-inch pipe or $1^1/_2$-inch angle iron for framework are common; and $^1/_2$-inch rods welded about 3 inches apart vertically make a good pen partition.

Dry sow housing

The trend today is to confined housing of dry sows. This reduces feed costs, because sows are less active when confined and feed is not required to maintain body heat in cold weather. It is much easier to maintain breeding and farrowing schedules with a sow under confinement where the operator can watch her more easily.

Dry sows are either grouped in pens or tied individually in stalls. Although tie stalls are more popular with large producers, who feel that it is easier to keep track of breeding and farrowing schedules when sows are individually tied up, most dry sows are housed in groups. The Canadian Farm Building Plan Service recommends housing no more than 5 to 6 sows together, in a pen providing 12 to 16 square feet per sow. If shoulder partitions are used, to keep sows apart while being fed, up to 20 square feet of total pen space per sow should be provided to allow room for sleeping.

Cost of swine housing

The cost of swine housing will change with economic conditions. However, at the time of writing, a modern, well-built hog barn costs about $4 per square foot,

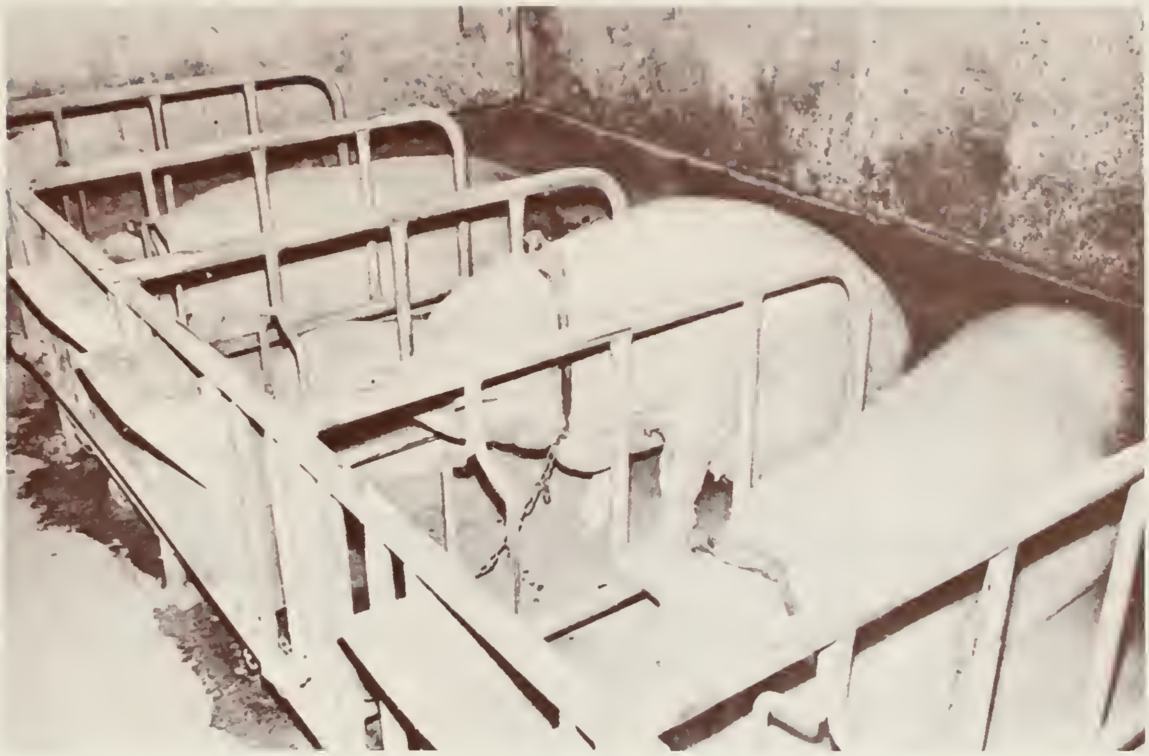

Figure 4. Dry sows tied up.

including material and labor, but excluding all equipment.

Swine accommodations

The general requirements for swine accommodations are shown in Tables 1 to 3.

Water supply

Be sure of adequate water of good quality before any buildings are constructed. Allow 2 gallons per day for each pig.

For cleaning purposes, supply 200 gallons per hour at 30 psi minimum pressure. In addition, a portable booster pump complete with high-pressure hose and nozzle is a useful aid for periodic cleaning of pens and equipment.

Have warm water available for washing sows just before moving to the farrowing area.

Heating and ventilation

The functions of a ventilation system are to maintain a desirable environment within the building regardless of outside conditions, and to control the moisture level or relative humidity in the building to protect it from deterioration.

For successful operation of a ventilation system:

- Keep the building filled to capacity in winter months. Since the heating and ventilation system of most livestock barns is designed so that the heat radiated by the animals is used to heat the ventilating air and overcome other building heat

Table 1. Space Requirements for Pigs

	Under 50 lb	50 – 200 lb
Total confinement, sq ft/animal		6 (50 – 100 lb)
Slotted, partly slotted, or solid concrete floor	3	8 (100 – 200 lb)
Partial confinement, sq ft/animal		
Shelter space	4	6
Outside pen (paved)	4	6
Total	8	12
Shade, sq ft/animal on pasture	4	6
Pasture, pigs/acre		
Grass	20 – 25	20 – 25
Legume	35 – 40	35 – 40
Watering space, pigs/cup	20 – 25	20 – 25
Self-feeder length	2 in/pig	3 in/pig

Table 2. Space Requirements for Sows

	Under 400 lb	Over 400 lb
Farrowing stall		
Space for sow	22″ X 7′	24″ – 26″ X 7′ – 8′
Creep areas	Two 18″ X 7′	Two 18″ X 7′
Total	5′ X 7′	5′ X 7′ – 8′
Movable house	7′ X 8′	7′ X 9′ to 8′ X 9′
Long pen	6′ X 12′ (6 sows)	6′ X 12′ (5 sows)
Shade-shelter, sq ft/sow	15 to 18	15 to 18
Drylot, sq ft/sow	50 to 100	50 to 100
Pasture		
Sows/acre	15 to 18	15 to 18
Sows with litters/acre	10 to 12	10 to 12
Feeding space, ft/sow	1 1/2	2

Table 3. Walkways and Alleys[1]

Sorting alleys for animal handling	24 in (sows) 20 in (market pigs)
Roads for vehicles	12 ft, minimum
Manure alleys for tractor scraping	8 ft, minimum
Inside alleys for pen access	3 – 4 ft
Inside alleys for creep access	2 ft

[1] Convenience must be balanced against cost in selecting alley width.

losses, it is essential that the ratio of exposed building surface area per animal be minimized.

- Insulate the walls and ceiling; use at least 4 inches of fiberglass (or its equivalent) in the walls and 6 inches in the ceiling.

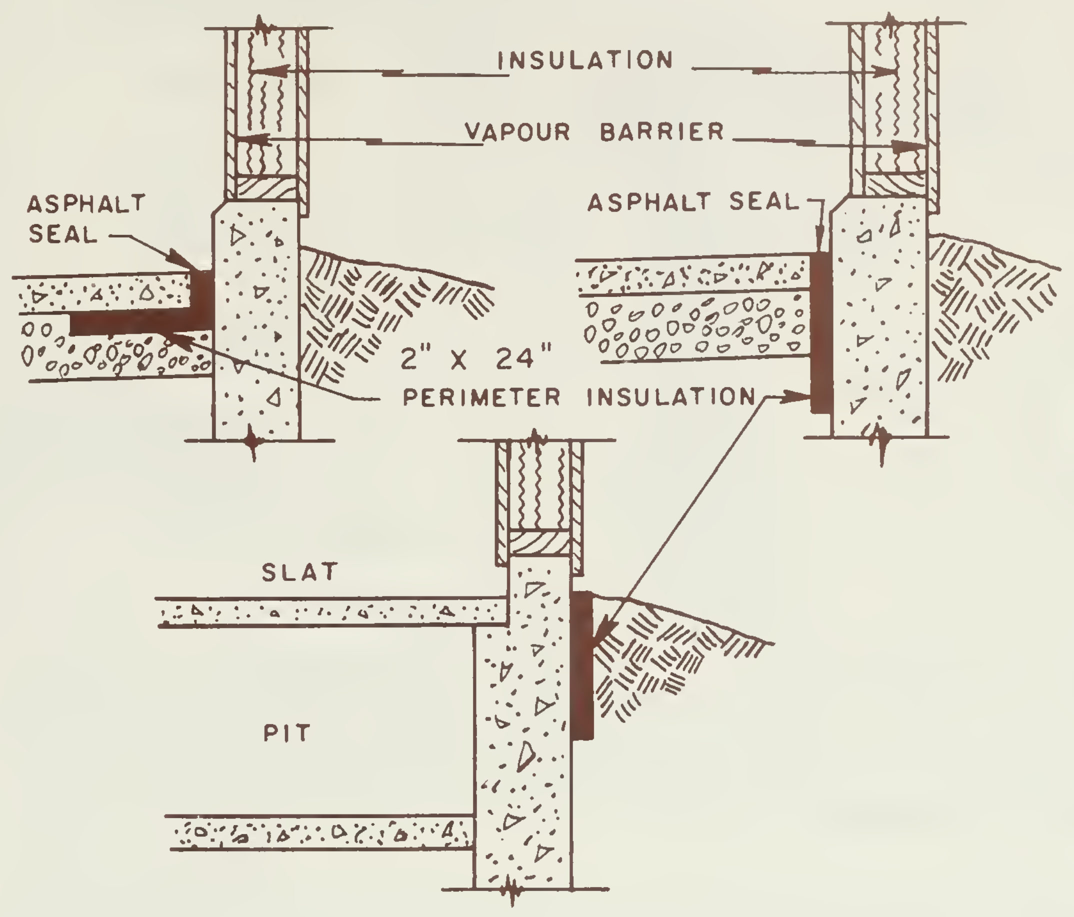

Figure 5. Insulation of floor or foundation wall.

- Provide a vapor barrier to keep the insulation dry. The most common material used is 4 mil polyethylene film.
- Insulate the floor or foundation wall as indicated in Figure 5. Floor insulation is needed where pigs or gutters will be near a cold outside wall. Install 2-inch rigid styrofoam insulation.
- Reduce the glass area to a minimum. Because of the high rate of heat loss through glass, windows should be eliminated from buildings housing livestock.
- Provide air intakes to admit fresh air. The disign of the air intake system must be such that it will provide for uniform distribution of draft-free air over a wide range of operating conditions. Provide 1 square foot of inlet slot area for each

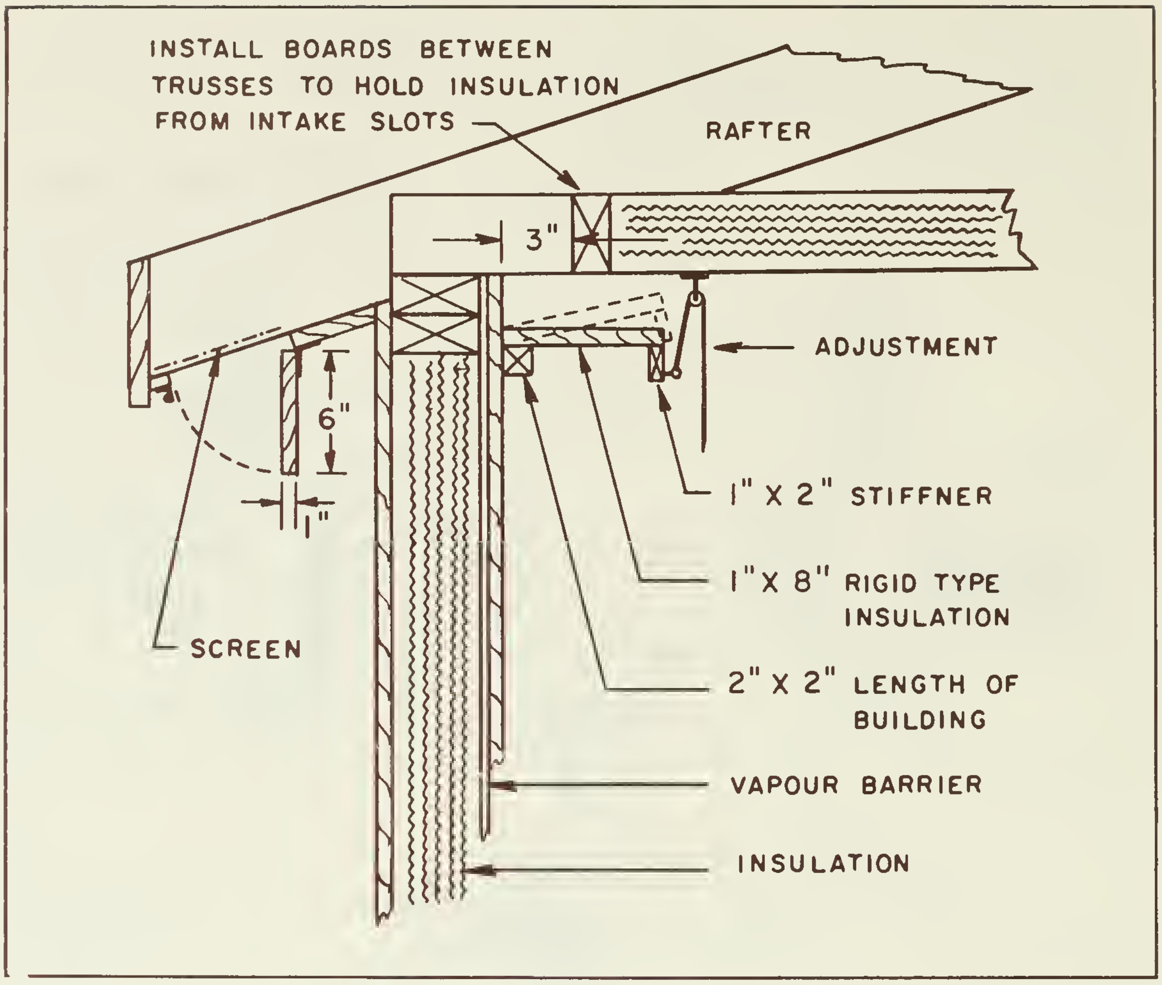

Figure 6. Adjustable air intake system.

500 cfm of maximum fan capacity, and provide adjustments for reducing the inlet area to 1 square foot for each 1000 cfm of winter ventilation. Install inlets that allow the incoming air to be tempered in the attic before being drawn into the building during cold weather. In hot weather air should be drawn into the building from inlets located below the eaves.

- Provide fans for forced air circulation. Recommended minimum barn temperatures and air flow rates for winter and summer conditions are shown in Tables 4 and 5. Fan capacities should be selected at a static pressure of 1/8 inch of water. All fans, except those running continuously, should be thermostatically controlled. A suggested exhaust system for continuously running fans is shown in Figure 7. Fan motors should be totally enclosed and have an overload protection device to prevent motor burnout and possible fire. Fan thermostats should be grouped in a central location in the building. If areas of a barn appear to be poorly ventilated, swivel-mounted circulating fans can be installed. Variable-speed fans and thermostatically controlled dampers are also available for integration into a ventilating system.

Table 4. Recommended Minimum Barn Temperature

Feeder and gestation	60°F – 75% RH
Weanlings	70°F – 75% RH
Farrowing	70°F – 75% RH

Table 5. Recommended Ventilation Rates

Class of swine	Ventilation rate cfm/unit			
	Winter			Summer total
	Min. cont. ventilation rate	Min. cont. fan capacity for moisture control	On thermostat	
Sow and litter	10	15	20	200 – 300
Weanlings 30-50 lb	1.5	3-4	10	25 – 35
Finishing 125 lb av.	3	5-6	25	50 – 70
Dry sow 350 – 400 lb	4	15	35	200 – 300

The use of variable speed fan motors or a throttled fan inlet, as shown in Figure 7, will allow a reduction in air flow on very cold days to help maintain the barn temperature. The thermostatically controlled fans are used to maintain temperatures during mild winter weather. Adequate capacity is also required for summer ventilation. Some swine barns have been equipped with evaporative coolers to assist in limiting summer temperatures, but they are effective only where himidity is very low.

- Supplemental heat during cold weather is required in farrowing and growing barns and is desirable in the finishing barn. The amount of heat required differs for various age groups of pigs. Consult provincial extension offices for Canadian Farm Building Plan recommendations. Many types of heaters may be used. For small pigs, brooder lamps and heated floors are commonly used. Underfloor heaters, unit heaters — either gas, electric or hot water, or a hot air furnace with a distribution system — may be used to maintain minimum temperatures in swine barns. Install heating systems so that ventilation fans will not cause back drafts through heater vents, which could extinguish the burner of draw in smoke or gas.

Where underfloor heating cable is used, a variety of cable layouts are possible. The layout selected depends on the number of pens and their arrangement. In general, it is suggested that a 2- to 3-foot strip be heated at the top end of pens containing weanlings or growing hogs. Part of the creep area in farrowing pens should be heated, and for farrowing crates a section 3- to 4-feet long on one or both sides of the sow should be adequate. Heating cable or hot water pipes in farrowing crates should not be placed in the area below the sow. Cable spacing for various watt densities are shown in Table 6.

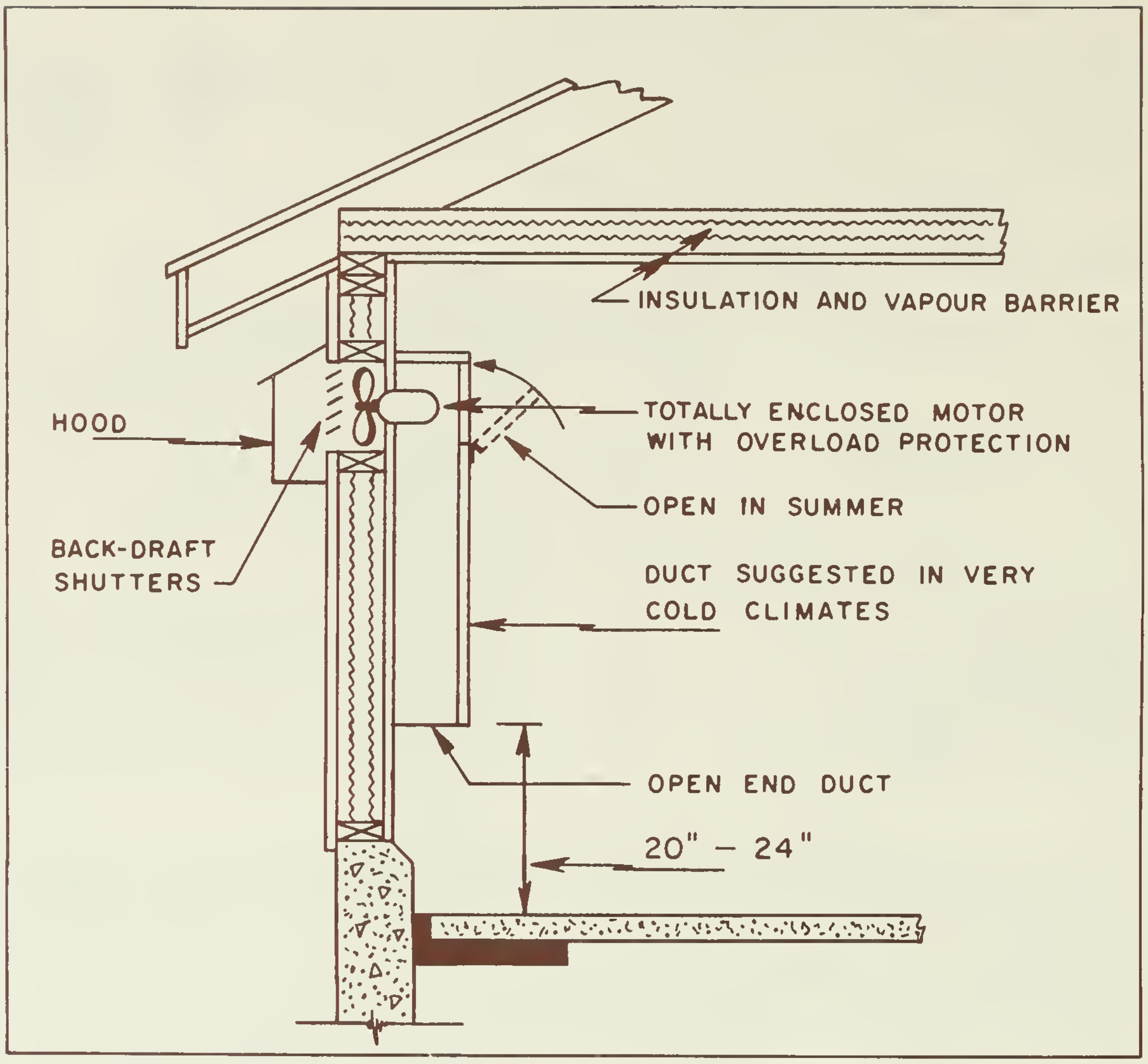

Figure 7. Exhaust fan installation for continuously running fans.

Table 6. Underfloor Electric Heating Cable

Watt density W/ft	Watts/lineal ft of heating cable							
	6	8	10	12	14	16	18	20
	Spacing between adjacent runs, inches							
15	$4^{7}/_{8}$	$6^{3}/_{8}$	8	$9^{5}/_{8}$	$11^{1}/_{4}$	–	–	–
20	$3^{5}/_{8}$	$4^{3}/_{4}$	6	$7^{1}/_{4}$	$8^{3}/_{8}$	$9^{5}/_{8}$	$10^{3}/_{4}$	12
25	$2^{7}/_{8}$	$3^{7}/_{8}$	$4^{3}/_{4}$	$5^{3}/_{4}$	$6^{3}/_{4}$	$7^{3}/_{4}$	$8^{5}/_{8}$	$9^{5}/_{8}$
30	$2^{3}/_{8}$	$3^{1}/_{4}$	4	$4^{3}/_{4}$	$5^{5}/_{8}$	$6^{3}/_{8}$	$7^{1}/_{4}$	8
35	2	$2^{3}/_{4}$	$3^{3}/_{8}$	$4^{1}/_{8}$	$4^{3}/_{4}$	$5^{1}/_{2}$	$6^{1}/_{4}$	$6^{7}/_{8}$
40	$1^{3}/_{4}$	$2^{3}/_{8}$	$3^{1}/_{8}$	$3^{5}/_{8}$	$4^{1}/_{4}$	$4^{3}/_{4}$	$5^{3}/_{8}$	6

Heating cable buried in concrete should be nylon or plastic covered, lead or copper sheathed, and thermostatically controlled.

Provision should also be made for the use of heat lamps above creep areas, to help newborn pigs find the heated area. Only CSA approved infrared lamp fixtures should be used, and they should be independently suspended by a chain or wire, not hung by the cord. Lamps should be located at least 18 inches from the litter or combustible material. Only pyrex glass bulbs should be used in livestock barns.

Floors may also be heated by circulating hot water through pipes buried in the concrete. Three-quarters or 1-inch copper, wrought iron, black iron or CSA-certified polyethylene plastic pipe may be used. Do not use galvanized iron or lightweight plastic pipe. Place pipe in at least 6 inches from the edge of a concrete slab and 2 inches from the top.

Provide adequate water circulating and heating equipment. A water temperature of 120°F and an input of 50 btu/per hour per foot of pipe should keep the floor temperature at 80°F. No pipe loop should be longer than 200 feet. The total footage of pipe times 50 btu per hour should equal the capacity of the water heater or boiler.

The circulating pump must supply 1 gallon per minute for each 10,000 btu per hour output. Valves should be located in a pit so the system can be drained. Rigid foam insulation should be placed below the concrete floor under the heated floor panels.

Consult a heating contractor for equipment and installation.

Feed handling

Handling and processing feed for a swine enterprise should be mechanized to reduce labor and to provide the proper ration at the right time for each group of pigs.

Feed handling systems for livestock may be divided into three operations:

- Storage and handling before processing.
- Processing the feed.
- Storage and distribution of the processed feed.

In planning, consider the overall system as a unit. Try to eliminate unnecessary activities or operations in the system. The most common difficulties and faults with existing systems usually can be traced to inadequate planning. The flow chart in Figure 8, which illustrates several feed handling systems in use, is useful in planning alternate systems. When a satisfactory plan has been developed, select commercially available equipment that will achieve the desired flow of materials.

Bulk feed storage

Bulk grain storage bins already exist on many farms and little can be done to coordinate them into an efficient system. Where new storage is being planned for a livestock enterprise, round steel storage bins provide practical storage units. Storage should be grouped for easy mechanical handling of grain into and out of storage. Bins that are grouped and near other buildings should be fireproof. Mechanical

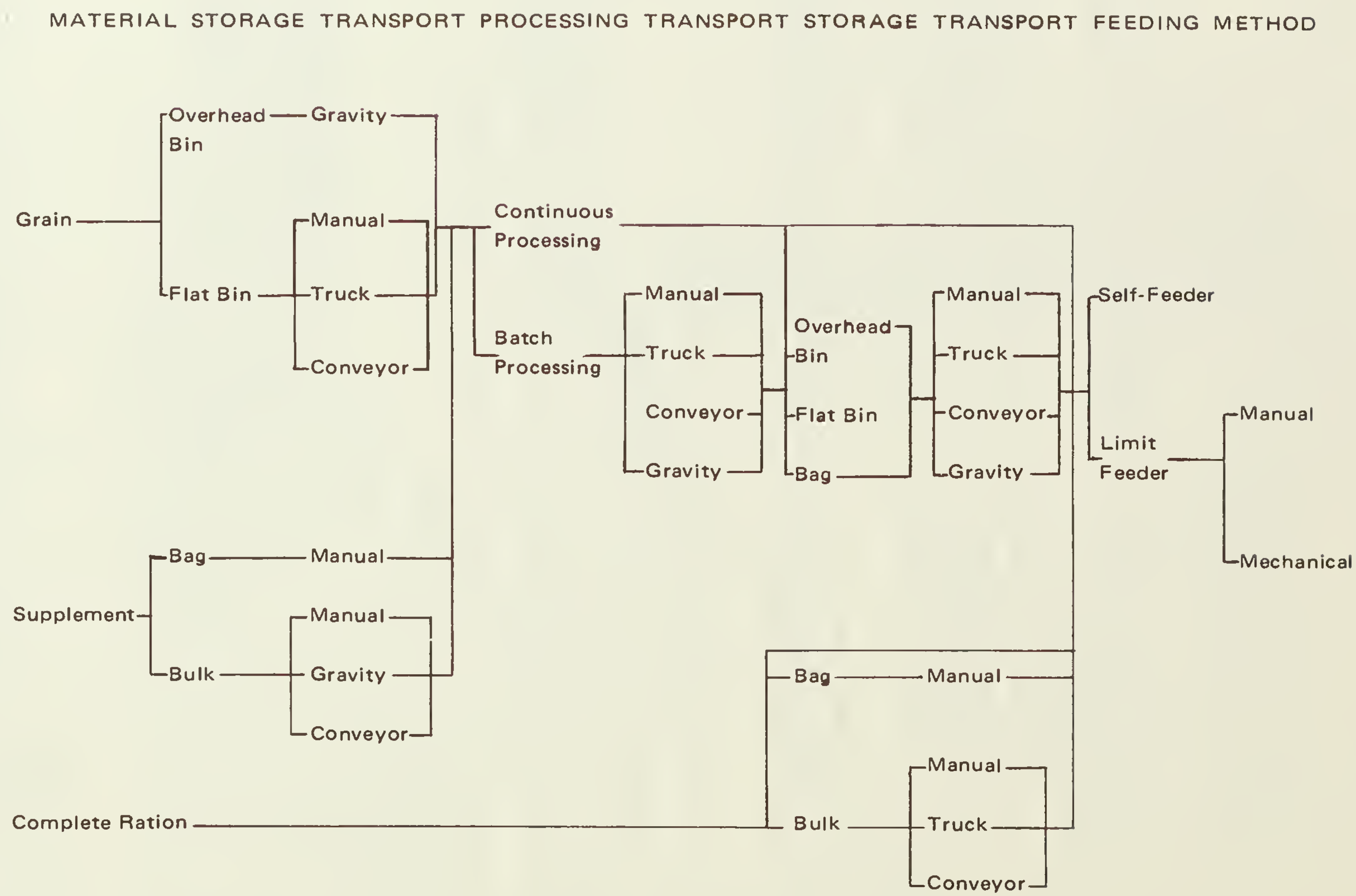

Figure 8. Feed handling systems.

unloading equipment should be installed in flat-bottomed storage bins, and all storage should be equipped with conveyors to move the grain to the processing center. Table 7 compares the capacity and cost of various kinds of grain storage buildings.

The volume of material to be stored and handled may be estimated from Table 8.

Table 7. Capacity and Cost of Farm Grain Storage Buildings

Type	Available capacity bu	Approx. cost/bu capacity[1]
Farm elevator	10,000 – 25,000	$2.25 – 1.25
Wood frame bin	500 – 5,000	.60 – .30
Flat storage	10,000	.40 – .25
Round metal bins	1,000 – 15,000	.40 – .25
Metal hopper bottom	100 – 4,000	1.65 – 1.00

[1]Cost depends on size, construction material and type of floor. Usually large capacities cost less per bushel.

Table 8. Material to Be Stored and Handled

Pig weight lb	Full feed lb/day
50	2.7
100	4.7
150	6.3
200	7.6
250	8.2
Sow bedding where used	1/2 ton/year

Feed processing

Swine feed may be purchased ready-mixed as a complete ration from a commercial feed distributor; or it may be processed on the farm in several ways:

- Continuous grinder-blender system.
- Weigh-grind-mix batch system.
- Tractor-driven portable grinder-mixer.
- Using services of a commercial mobile feed mill.

If under 100 tons per year of feed is to be processed, it is not likely to be economical to own your own processing equipment, unless commercial services are not available. Table 9 may be used to estimate processing cost but the final decision should be based on the results of a partial budget to estimate the processing and storage costs for different systems.

Table 9. Investment and Annual Costs for Processing Concentrate Feeds

System	Output tons/hour		50 Invest-ment	50 Cost/ton[2]	100 Invest-ment	100 Cost/ton	200 Invest-ment	200 Cost/ton	400 Invest-ment	400 Cost/ton	800 Invest ment	800 Cost/ton
Small electric mill, volumctric	0.5–0.6	Process	$ 805	$2.43	$ 850	$1.32	$ 975	$0.78	$1295	$0.54	$1675	$0.37
		Storage	645	1.67	1290	1.08	2060	0.87	2660	0.56	3320	0.35
			1450	4.10	2140	2.40	3035	1.65	3955	1.10	4995	0.72
Small electric mill with mixer and scale		Process	955.	2.93	1000	1.52	1200	0.93	1995	0.79	2385	0.57
		Storage	645	1.67	1290	1.08	2060	0.87	2660	0.56	3320	0.35
			1600	4.60	2290	2.60	3260	1.80	4655	1.35	5705	0.92
Tractor mill, batch mixer and scale	3.0	Process	1130	3.38	1900	3.85	2000	2.50	2100	1.79	2200	1.43
		Storage	625	1.62	1250	1.05	2000	.85	2500	0.51	3000	0.32
			1755	5.00	3150	4.90	4000	3.35	4600	2.30	5200	1.75
Mobile grinder-mixer, or tractor grinder and separate mixer wagon	3.0–4.0	Process	1480	5.53	1480	3.50	1480	2.40	2320	1.89	2320	1.48
		Storage	625	1.62	1250	1.05	2000	0.85	2500	0.51	3000	0.32
			2105	7.15	2730	4.55	2480	3.25	4820	2.40	5320	1.80
Mobile custom mill		Process[3]		4.00		4.00		3.50		3.50		3.50
Custom feed plant (hauling extra)		Process[3]		4.60								
		Pelleting		4.00								

[1] Total investment. Process – mills, augers, controls, spouting and electrical wiring. Labor and distribution costs are not included.
Storage – storage bins for feed and grain. Housing for mill is not included.

[2] Depreciation. – 10 years for equipment, 20 years for storage. Interest 7% on the average value. Repairs 2% of original cost.
Insurance – 50 cents/$1,000. Operating costs 1 cent/Kwh or $3/hour for tractor and operator.

[3] Includes grinding and mixing.

Feed processing equipment

Before purchasing processing equipment, consider the products to be processed, the capacity required, and the desired characteristics of the finished feed. In general, grain should be ground fine enough to kill the germ, particularly if weed seeds are present. There is evidence that very fine grinding of barley reduces problems with the hulls in liquid manure handling. Sometimes feed is ground too fine, however. Fine grinding increases power requirements, decreases equipment capacity and results in dustiness during limit feeding.

The following types of processing mills are used:

Hammer mills are the most popular for grinding swine feeds. Several low-power, 2- to 5-hp units are marketed both with and without blending equipment. They have the advantage of simple construction and are not easily damaged. Small units may be coupled directly to the motor, eliminating drive belts. However, hammer mills do not produce a uniform grind and considerable dustiness results. Rates of grinding for various horsepower hammer mills are compared in Table 10.

Table 10. Approximate rates of grinding in lb/hr for a hammer mill

		Motor HP				
Grain	Classification	1	$1^1/_2$	2	3	5
Barley	Coarse	300	500	600	900	1400
	Fine	75	100	150	250	500
Oats	Coarse	300	450	600	1000	1500
	Fine	75	110	225	350	450
Wheat	Coarse	600	1000	1600	2400	3000
	Fine	200	225	600	850	1000
Corn	Coarse	600	900	1650	2500	3500
	Fine	250	300	620	900	1200

Burr mills provide a more-uniform grind than hammer mills but cost more to buy and operate. The plates are fairly easily damaged and must be replaced when worn.

Roller mills are more suitable for the production of cattle feed than feed for swine.

Oat hullers are used occasionally to break the hulls from oats where the groats are used for feed.

Pellet mills – Pelleted mixed feed reduces waste, is convenient to handle and usually results in increased feed consumption and efficiency. However, pellet machines are very expensive and, therefore, not practical for farm installations.

Metering or blending, and mixing

Metering or blending of feed ingredients to produce a complete ration can be accomplished by weight or by volume. Volumetric methods are the simplest; however, frequent calibration checks are required to insure the desired ration is being maintained. Gravimetric, or weighing, methods are usually associated with a batch system.

Volumetric systems – Grain or concentrate may be metered into a processing system using a bucket wheel or rotary feeder; screw, belt or drag-chain conveyor; or vibratory feeder, in which the feed rate is controlled by a gate and/or by varying the amplitude of vibration.

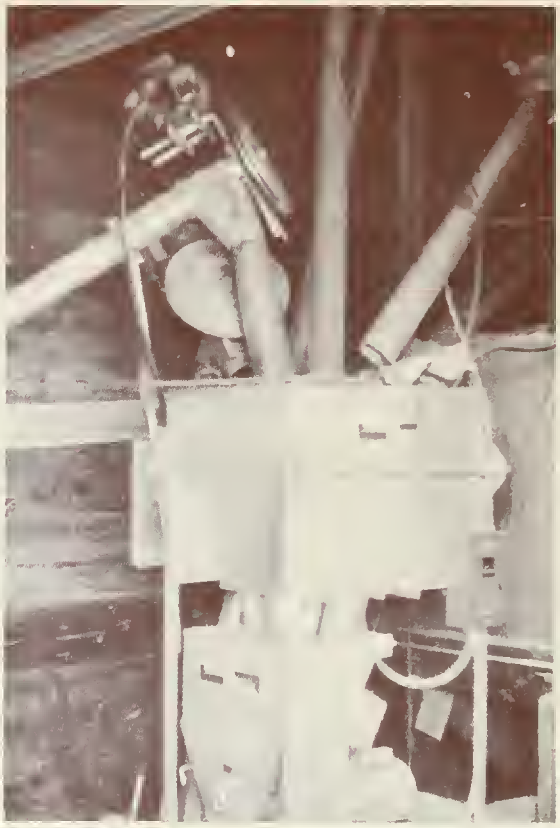

Figure 9. Automatically controlled augers bring feed ingredients from supply bins to automatic mill.

A number of small hammer mills are marketed with a volumetric metering system attached to the mill. These units are well suited for a semiautomatic feed processing system that has a feed ingredient supply to the mill, either from overhead bins or augers controlled by bin switches. Figures 9 and 10 illustrate the above systems.

Gravimetric system – A scale-mounted, hopper-bottomed bin as shown in Figure 11 may be used to weight feed ingredients before processing through a hammer mill and into a mixer. The capacity of the mixer determines the size of the batch.

Either a vertical or horizontal mixer can be used. A vertical mixer is less expensive and requires less power than a horizontal mixer. However, mixing time is longer (15 minutes compared with 3 to 5 minutes), and the vertical type is not suitable for mixing wet materials such as molasses.

Portable grinder mixers – These mixers (Figure 12) can be operated from the p.t.o. of a tractor and have several other advantages. However, they are expensive to buy and are more suitable for cattle feeding operations than for swine.

Continuous mixers – Occasionally a cut-flite auger may be used to mix dry materials in transit. High-speed paddle mixers can be used to mix liquids such as molasses, fats or water with dry ingredients.

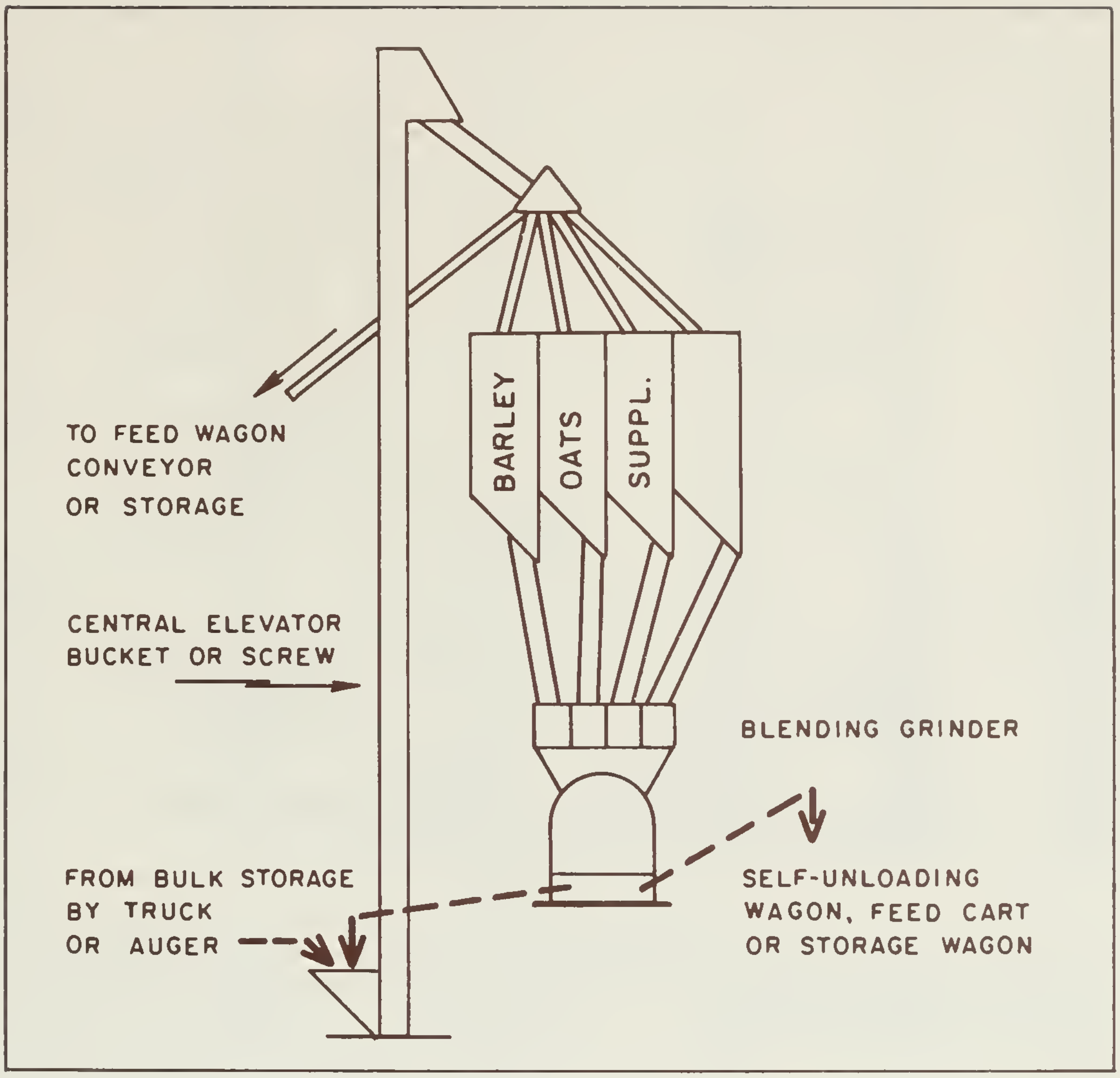

Figure 10. Blender-grinder system.

Feed distribution

Feed may be conveyed and distributed by several methods:

- Hand-fed directly from storage bins.
- Hand-fed from a cart.
- Conveyed by auger, drag flight or other means to self-feeders.
- Conveyed to limit-feeding equipment.
- Conveyed pneumatically to bins or self-feeders.

Conveyors – Bucket elevators are the most efficient method of conveying feed vertically. Although augers are less efficient, their cost is low and power requirements are not high for most farm processing systems. Pneumatic conveying systems are useful to convey feed where distances exceed 200 to 300 feet. The following tables will be found useful in selecting a conveyor.

Self-feeders – Self-feeding is a popular method of feeding hogs, particularly during the growing stage or when numbers are small. Figure 13 shows two lines of

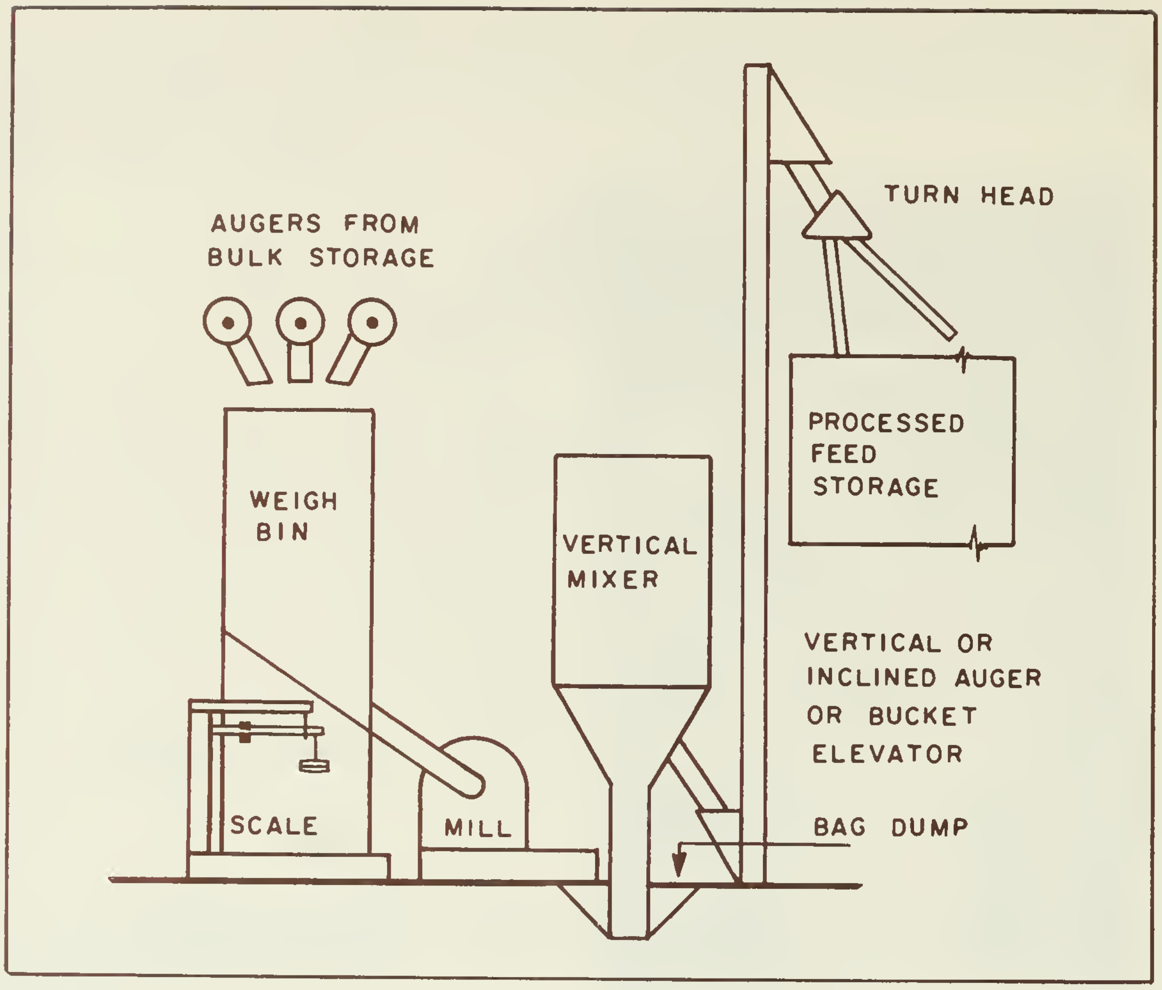

Figure 11. Weigh-grind-mix system.

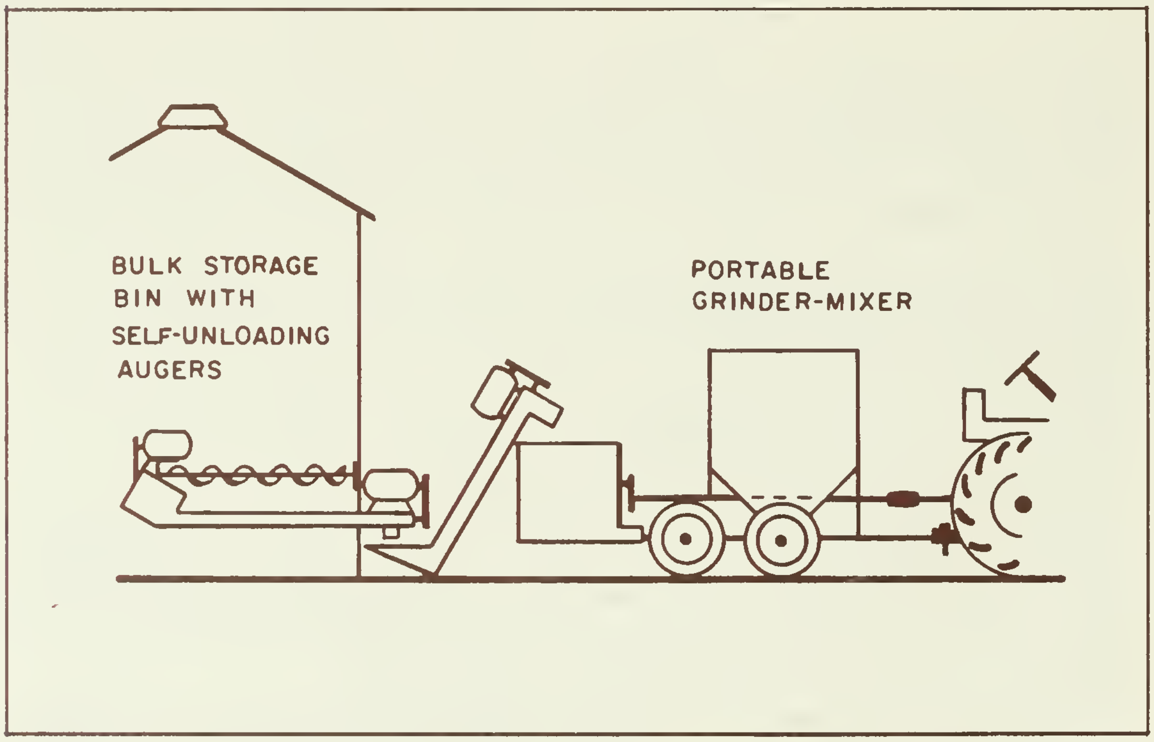

Figure 12. Portable grinder mixer.

Table 11. Maximum capacity and power requirements of 4-inch auger conveyors

Speed rpm	Angle from horizontal	Approximate HP/10-ft length	Maximum capacity, bu/hr		
			Wheat	Oats	Mash
	0	0.22	220	200	220
	30	0.26	170	160	230
300	45	0.26	140	140	190
	60	0.25	105	105	160
	90	0.21	60	40	40
	0	0.28	290	260	290
	30	0.34	215	200	335
400	45	0.34	190	170	270
	60	0.32	150	130	215
	90	0.28	80	60	170
	0	0.35	420	340	500
	30	0.46	300	270	525
600	45	0.47	250	220	390
	60	0.46	205	175	325
	90	0.41	140	90	240
	0	0.42	435	355	700
	30	0.55	345	300	650
800	45	0.62	300	265	500
	60	0.58	245	205	205
	90	0.43	165	115	290

Table 12. Maximum capacity and power requirements of 6-inch auger conveyors

Speed rpm	Angle from horizontal	Approximate HP/10-ft length	Maximum capacity, bu/hr		
			Wheat	Oats	Mash
	0	0.50	810	770	890
	30	0.53	595	570	780
300	45	0.60	490	470	600
	60	0.52	370	345	550
	90	0.45	230	230	500
	0	0.60	1000	900	1030
	30	0.71	710	650	880
400	45	0.70	580	530	670
	60	0.64	460	405	600
	90	0.55	330	270	560
	0	0.80	1130	1050	1270
	30	0.85	850	730	960
600	45	0.90	690	600	820
	60	0.86	575	470	720
	90	0.80	450	340	650
	0	0.64	1100	1000	
	30	0.98	870	735	
800	45	1.03	715	600	
	60	1.05	593	480	
	90	1.01	465	355	

Table 13. Performance characteristics of 4-inch auger with limited feed flow[1]

Feed flow rate	Angle of incline	Approx. power required for ground feed at 300 rpm
lb/hr	degrees	
1500	0	1/4 hp/80 ft
	30	1/4 hp/40 ft
	45–90	1/4 hp/25 ft
2500	0	1/4 hp/70 ft
	30	1/4 hp/30 ft
	45–90	1/4 hp/20 ft
3500	0	1/4 hp/60 ft
	30	1/4 hp/25 ft
	45–90	1/4 hp/10 ft

[1]Adapted from Herum F. L., Performance of auger conveyors for farm feed materials at restricted delivery rates. Illinois Agri. Exp. Station. Bulletin 666, 1960.

Table 14 Approximate capacity and horsepower requirements for bucket elevators[1]

Capacity bu/hr	Bucket W X L in in.	Lift, in ft 15	20	25	30	40	50	60
200	3 X 4	1/3	1/3	1/2	1/2	1/2	3/4	1
400	4 X 5	1/2	1/2	3/4	3/4	1	1 1/2	1 1/2
600	4 X 6	1/2	1/2	3/4	3/4	1	1 1/2	2
800	4 X 7	3/4	3/4	3/4	1	1 1/2	2	2
1000	5 X 9	1	1 1/2	1 1/2	1 1/2	2	2	3
12000	5 X 9	1	1 1/2	1 1/2	2	2	3	3

[1]This table is useful to estimate the performance characteristics of bucket elevators, in selecting motors for specific equipment use the manufacturers specifications.

Table 15. Approximate capacity and power requirements for high volume low pressure pneumatic conveyor

Pipe size, in.	HP/100 ft[1]	Capacity, lb/hr
4	1	3500
5	1 1/4	4500
6	1 1/2	6500

*Add 1/3 HP for each 1000 lb of feed conveyed per hour.

[1]Adapted from Kleis, R.W., Operating characteristics of pneumatic grain conveyors. Illinois Agric. Exp. Station. Bulletin 594, 1955.

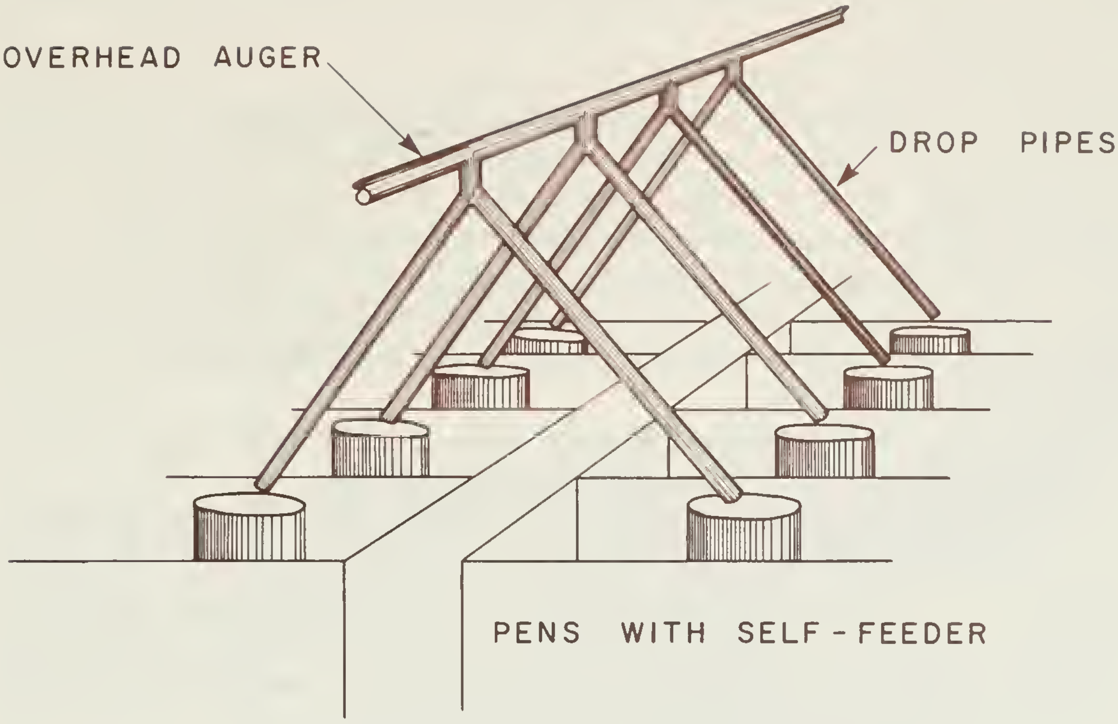

Figure 13. Overhead feeding system with pipes leading to self-feeders.

Figure 14. Interior of a confinement swine building showing mechanical limit feeders.

self-feeders being supplied from a single overhead auger with gravity conveyor pipes to the self-feeders.

Self-feeders should be large enough to require filling only twice a day. There should be 2 to 3 inches of feeder trough per pig. Control should be arranged for manual start and automatic stop when the feeders are full.

Limit feeding – Limit feeding, or feeding about 70 to 90 percent of the normal ration per day, is often used during the finishing phase of swine production.

Feed is pre-metered into containers located over each pen and dropped onto the floor of the pen several times each day. Since the swine are hungry they tend to clean up the feed quickly with little waste. Some veterinarians suggest that the method is not very sanitary.

Research shows that carcass quality may be improved; however, feed conversion does not appear to be increased and rate of gain is decreased.

A variety of limit feeding equipment is available. Basically, the equipment consists of an auger or drag-flight conveyor that runs the length of the barn above the pens. A box or feed drop is located over each pen. The amount of feed in each drop can be adjusted to feed the pigs a predetermined amount depending on the number in the pen and their stage of growth. The system is usually arranged so that feeding is automatic and controlled by a time clock.

Liquid feeding – Liquid feeding systems, as illustrated in Figures 15 and 16, are new and research to evaluate economic aspects of such systems is still in progress. Speer (1969)[1] reports a survey of published results indicating that when feed intake is limited, pigs fed liquid diets gained more rapidly than pigs fed dry diets. The feed efficiency response was varied, but the average response would favor liquid feeding. When self-feeding was practiced, no advantage was evident for either the liquid or dry diet. Liquid feeding also had no effect upon carcass quality.

Advantages claimed for the liquid system:

- Less dust than with dry feeding systems.
- Feed can be easily distributed by pipeline from a central mixing station.
- System is more sanitary than dropping feed on the floor.
- The feed trough can be used as a pen divider and provides a feeding station for each pig.
- Management may be improved since the operator is present when the pigs are fed. Fully automatic systems, however, are available.
- Administration of antibiotics is simplified.

Disadvantages:

- Some liquid systems require more labor than a dry feeding system because feed and water must be batch-mixed and distributed to each pen.
- The complete system must be flushed with water at least once a day.
- For good mixing and distribution, the feed has to be ground finer than for dry feeding (but this may not be a disadvantage since there are less problems with liquid manure systems when the feed is finely ground).
- Unless pens are separated by solid partitions, pigs limit-fed with a liquid system that will allow only two pens to be fed at one time may develop considerable stress.

[1]Specer, V.C., Liquid Feeding Pigs: Present Status Feedstuffs, 41 (8), 1969.

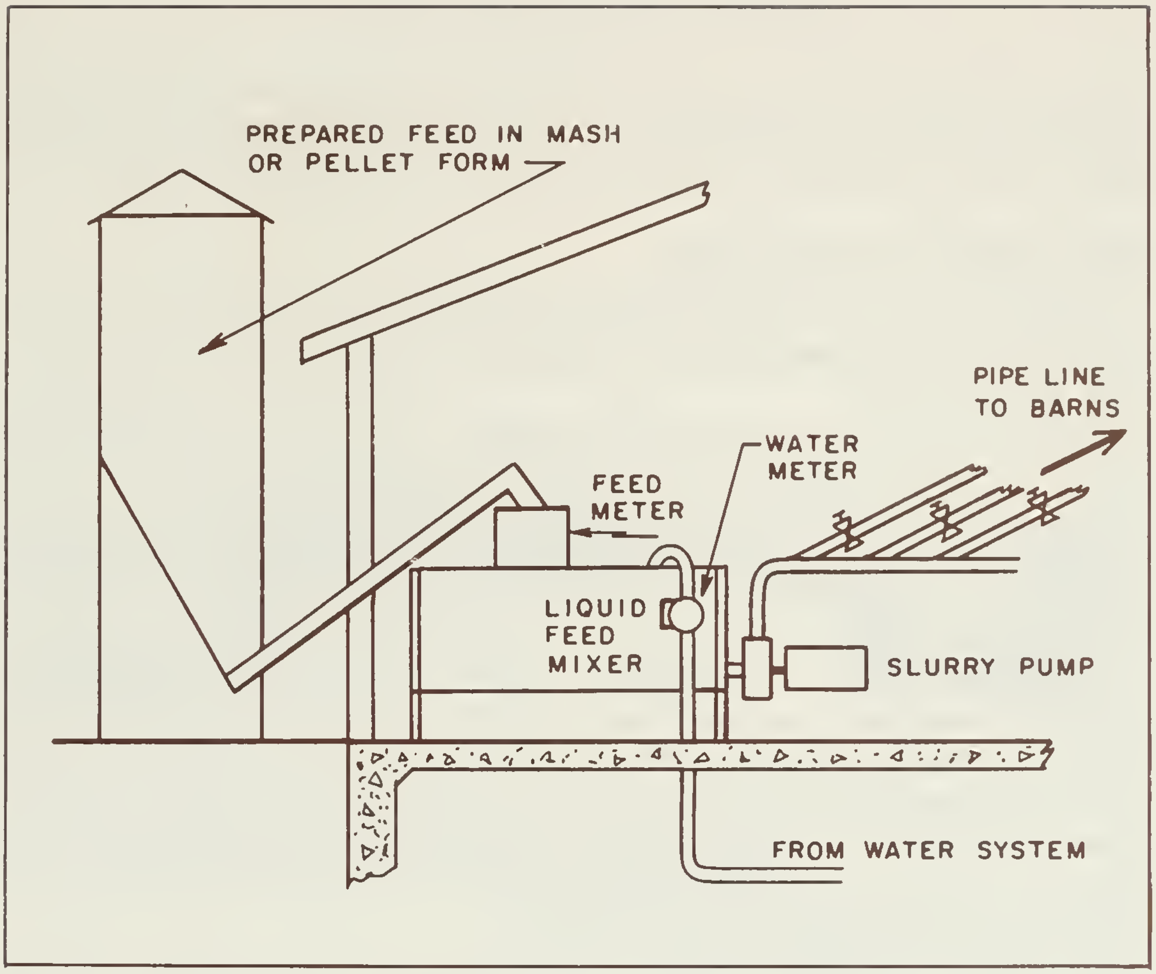

Figure 15. Feed mixer for a liquid feeding system.

Figure 16. Strip feeder for a liquid feeding system.

SWINE MANURE DISPOSAL

Swine manure disposal is a major problem for the producer who raises large numbers of hogs in confinement. Swine manure may be disposed of by a solid or liquid system. A barn must be constructed to allow use of the chosen system.

Solid manure disposal systems

Farmers who use straw bedding dispose of solid manure by using hand tools such as a pitchfork, shovel, scraper and wheelbarrow; or by using mechanized equipment, such as the following:

Tractor, front-end loader and manure spreader – The manure is scraped from the pens daily into a central alley or side alleys, 6 to 8 feet wide, then removed by the tractor and front-end loader. Disadvantages are: too much cold air enters the barn in winter when large doors are opened for the tractor; wide alleys make the barn harder to heat because less space is occupied; and this waste space increases the per hog cost of construction.

Chain gutter-cleaner or shuttle-stroke cleaner and a manure spreader – The manure is scraped into the gutters and moved by a gutter cleaner out of the barn and up a ramp to a manure spreader. Disadvantages are: freezing often causes mechanical breakdown of the drive unit located outside; and it is difficult to elevate liquid up the ramp. This system is fairly popular and reasonably successful where plenty of bedding is available. The gutter cleaner must be covered or guarded to prevent carrying small pigs into adjacent pens.

Liquid manure disposal systems

Most large modern hog barns have one of the following liquid manure systems:

Partly slatted floors and storage gutters – A gutter 4 to 6 feet deep and 4 to 5 feet wide is constructed along the outside wall or in the center of the barn. Outside gutters are preferable because they are easier to empty and because one wall of the gutter serves as a building foundation. The floor over the gutter is slatted. Most of the manure is dropped on the slats and then tramped through the slats into the gutter. The solid floor portion of the pens must be scraped and the slats washed occasionally. Gutters will store the manure 1 to 2 months. Cleanout openings through the foundation to the storage gutters are located 15 to 20 feet apart. The manure is sucked out through these openings by vacuum tanker and hauled to the field.

The advantages of this method – low cost and simplicity – seem to outweigh the disadvantages – excessive odor and the possibility of poisonous gases rising into the barn. The system is widely used where only 1 to 2 months' storage is adequate. However, many areas in Canada require storage for up to 6 months because heavy snow in winter and soft ground in spring delay field spreading of manure.

A recent development in storage gutters is to connect them together at the ends, make them wider, and install an oxidation rotor in the gutter. The oxidation rotor mixes air into the circulating manure, encouraging aerobic bacterial action. Recent research and farm experience indicate that with proper design (rotor size and

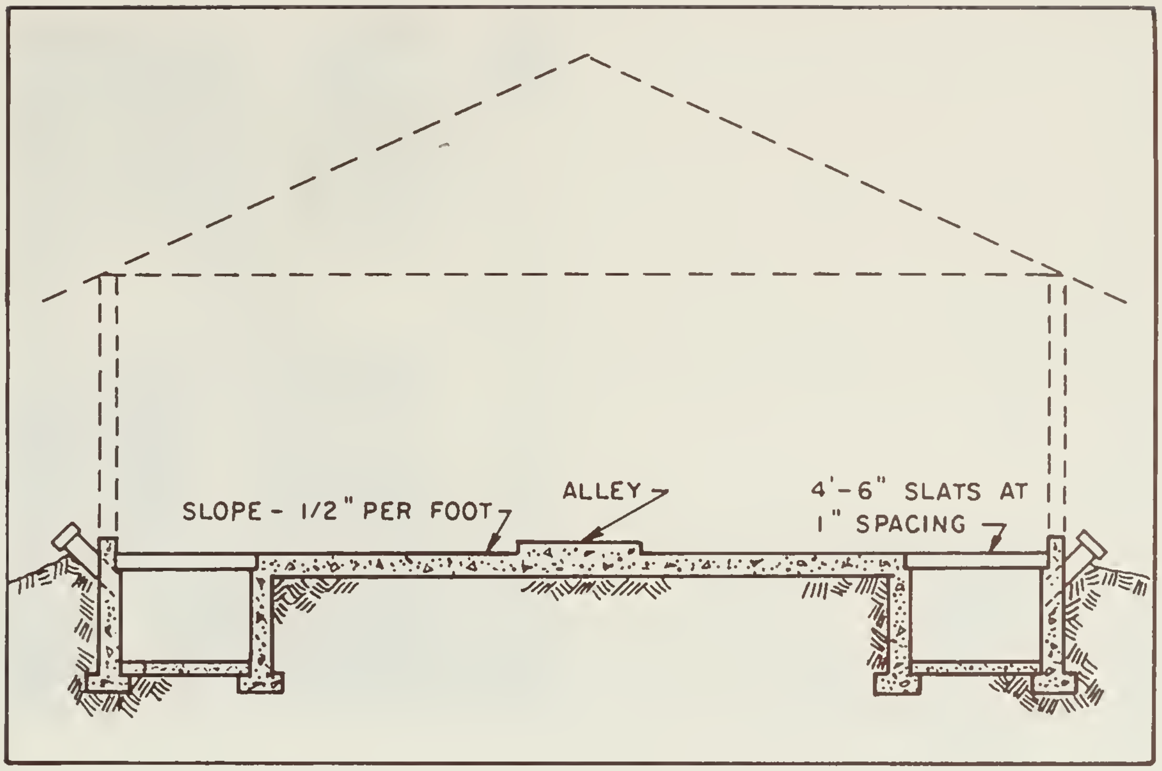

Figure 17. Cross-section of partly slatted floor and storage gutters.

horsepower, depth of liquid and depth of rotor immersion), this system reduces odor and poisonous gases. Operational problems, such as foaming, can result from inadequate aeration capacity or interrupted operation. Disadvantages are the cost and maintenance of the extra equipment and the cost of the power required (at least 10 horsepower continuous for system handling manure from 500 hogs).

Partly slatted floors, gutters and storage tanks – The slatted floors and gutters may be along the outside walls or in the center of the barn. A gutter about 2 feet deep and 4 or 5 feet wide is located below the slats. The bottom of the gutter slopes about $^1/_8$ inch per foot towards an under-floor storage or, better still, to an outside storage. The storage tank should be large enough to hold up to 6 months' manure production.

The manure is accumulated in the gutter for a few days, then a gate is opened and the liquid manure flows into the storage tank. The tank or cistern should be large enough to hold the manure produced during 2 to 4 months. Advantages are: less odor and less danger of gas poisoning than in method 1. Disadvantages are: storage tanks are costly, manure settles and is difficult to agitate to allow pumping, and the manure does not always flow readily from the gutter to the tank.

Partly slatted floor, gutters and lagoon – The slatted floor and gutters are the same as in method 2. A 6-inch or larger tile drain, sloping at about $^1/_4$ inch per foot (2 feet per 100 feet), drains from the gutters to a lagoon. A minimum land slope of 4 feet per 100 feet limits the application of this method on level land. The manure is accumulated for a week or so in the gutter, then a gate or plug is opened and the liquid manure flows to the lagoon. Disadvantages of this system are: long drains

Figure 18. Washing down pens and gutters with water under high pressure.

freeze and plug, lack of aerobic bacterial action causes the lagoon to fill with manure and oat hulls, and the odor level is high.

High-pressure pump, open gutters and storage tank – Water under pressure of at least 100 psi and 5 gpm will wash manure from the pens and gutters to a storage tank. This system is inexpensive, but requires considerable labor; it creates high humidity in the building and requires an abundance of water; and it is not suitable for long-term storage.

Deep, narrow gutter and storage tank – A gutter 6 to 8 inches wide and 2 to 3 feet deep cleans better than a wide, flat gutter. A pipe (swine guard) is installed over the center of the gutter to keep out small pigs. A watertight gate or plug valve is kept closed until the gutter is almost full (a few days only). The plug is opened and the manure flows rapidly to a storage tank adjacent to the building. This system requires considerable labor to scrape manure into the gutters daily. It has the advantage of less odor than storage gutters.

Drainage of liquid manure over the side of a hill can contaminate streams and water supplies, and is illegal in most provinces. Operators disposing of manure this way run the risk of prosecution and can be forced to close.

Slatted floors

For a partly slatted floor, about 25 percent of the pen floor area is slatted. The most widely used barn design has a central feed and service alley with pens on each side, and floors sloping $^1/_3$ to $^1/_2$ inch per foot from the alley to the slatted section.

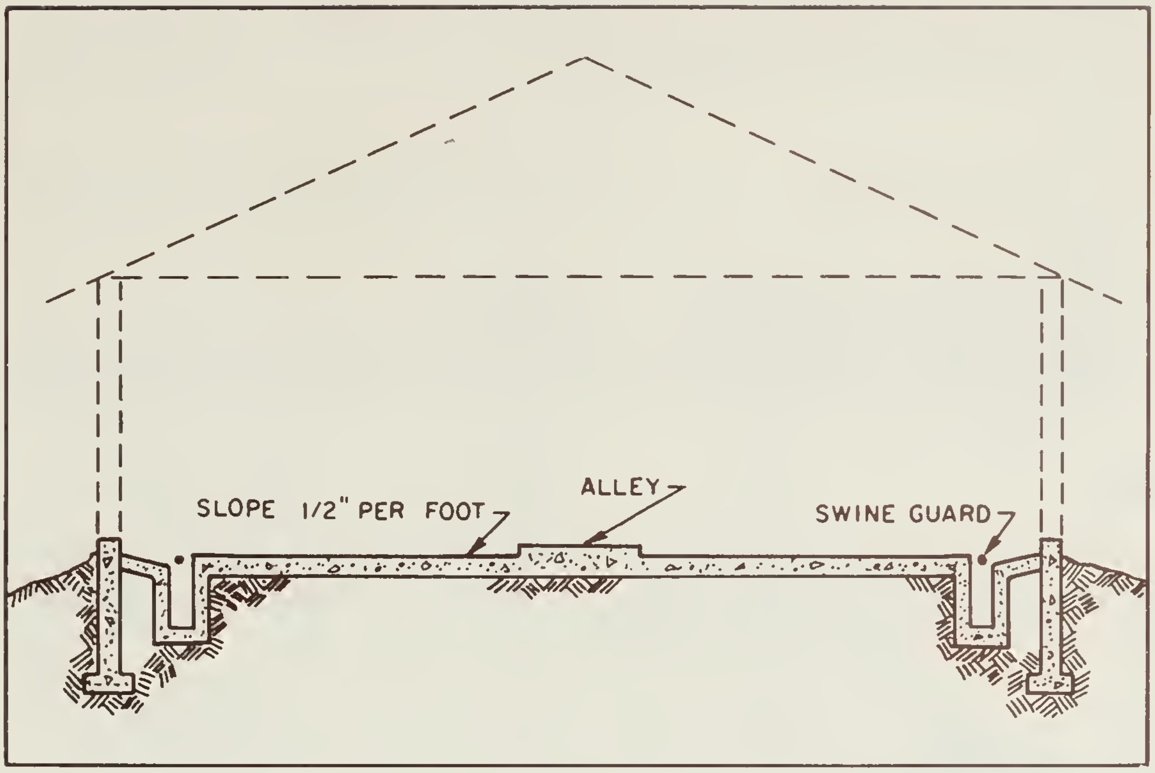

Figure 19. Deep narrow gutter.

Figure 20. Long narrow pen with slatted floors.

The slatted section should be 1 to 4 inches lower than the solid concrete floor. Where possible, to encourage cleaner pens:

- Place water bowls over the slats on the pen partition about 1 foot from the end of the pen.
- Use long, narrow pens.
- Crowd swine in the pen so that they cover the unslatted part of the pen when resting.
- Use floor feeding.
- Locate air inlet slot so that air can be directed first to the unslatted plan part. This way pigs can breathe fresh air, uncontaminated by dangerous gases from the trench under the slats.

Slats

Precast concrete is recommended over other materials for slats because it does not rust, decay or wear. Slats can be made by the farmer or contractor if he has good forms and follows recommended practices.

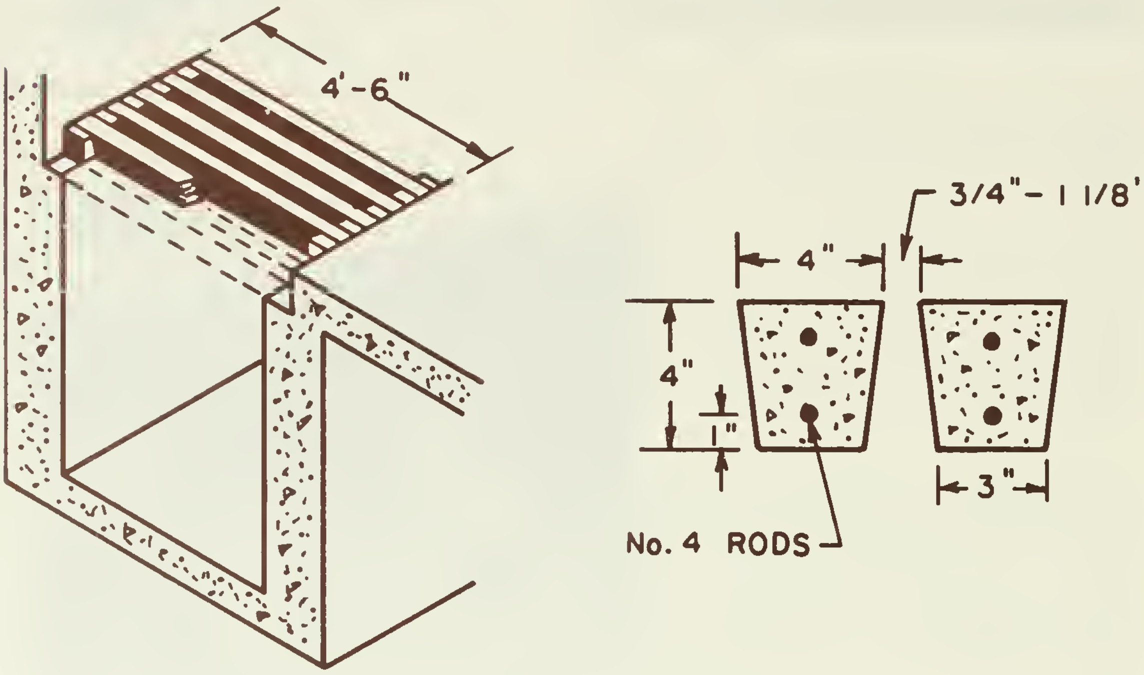

Figure 21. Concrete slats.

Concrete slats should be about 4 inches wide and spaced $^3/_4$ inches apart for weanlings, 1 inch apart for finishing swine and up to $1^1/_8$ inches for sows.

Manure storage tanks

Storage tanks should be built of sulphate-resistant, reinforced concrete. Concrete block is not recommended. Since considerable knowledge of concrete and methods of installing reinforcing rods is required to build a large tank, it is advisable to employ a concrete contractor.

The tank should hold all the manure produced in 2 to 6 months, depending on local climate and regulations. See Table 16 for estimating manure production of pigs.

Table 16. Manure Production and Storage[1]

Class of swine	Manure production, cu ft/animal day	Required storage for liquid manure, cu ft/animal day[2]	Required storage for solid manure including bedding, cu ft/animal-day
40 - 200 lb (8–22 wk)	0.18	0.25	0.25
10 - 25 lb (3–6 wk)	0.04	0.055	
25 - 50 lb (6–9 wk)	0.08	0.11	
51 - 75 lb (9–12 wk)	0.12	0.17	
76 - 125 lb (12–16 wk)	0.18	0.25	
126 - 175 lb (16–20 wk)	0.26	0.36	
176 - 200 lb (20–22 wk)	0.32	0.45	
Dry sow	0.40	0.56	0.48
Nursing sow and litter			
(wean at 3 wk)	.55	0.77	
(wean at 6 wk)	.69	0.97	

[1] Table provided by Canadian Farm Building Plan Service.
[2] This column is calculated from 'Manure Production' by a multiplying factor of 1.4 to allow for water spillage from waterers, floor washing, and dilution water where required.

The manure storage tank should be located outside the barn for easier agitation and emptying. It may be covered with about a foot of soil or baled straw to reduce freezing.

A rectangular tank, 8 to 12 feet deep and 20 to 25 feet wide, is recommended. Limitations of available agitation equipment make it necessary to divide the tank into compartments not larger than 25′ X 50′. Where 6 months' storage is provided, a cover is not an absolute requirement since the farmer can wait for the manure to thaw before pumping. However, open-top storages must be fenced for safety and remote from neighbors who can complain of odors.

Other manure storage systems are described in a Canadian Farm Building Plan Service bulletin. For more information, consult provincial extension offices.

Removal of manure from storage

Liquids and solids separate in storage, and, therefore, the contents must be agitated before emptying.

Augers – When using an auger, it is not possible to agitate the manure in the tank. In winter, the flighting freezes to the tube between loads. Grain augers have a short life when used for this purpose, so are not recommended.

Pumps – A 3- to 4-inch manure pump may be used. To agitate the manure, a tee and valve are placed in the outlet so that all or part of the liquid manure may be returned to the tank.

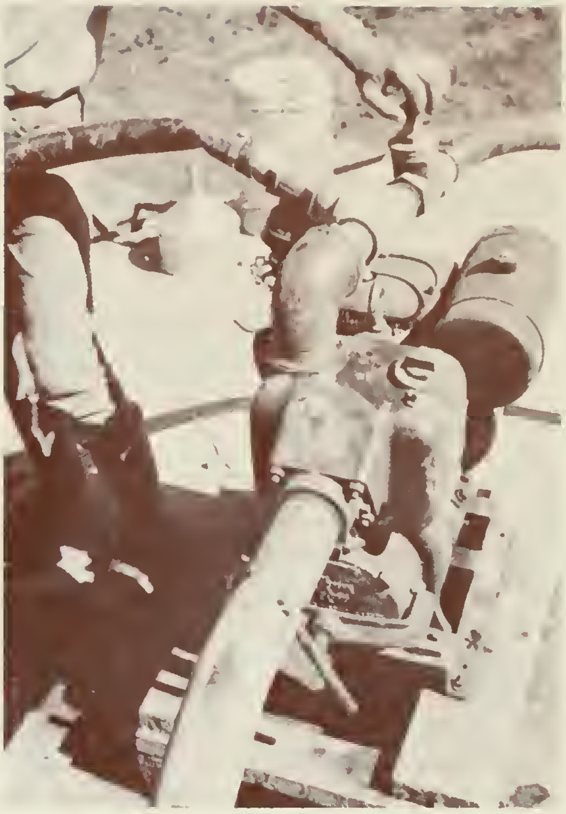

Figure 22. Liquid manure pump.

In winter, the pump may freeze between loads. These pumps cost $400 to $600. A tanker is also required.

Trailer-mounted vacuum tanker – The vacuum tanker has a power take-off driven pump mounted in or on a tank trailer. The pump creates a vacuum to fill the tank and pressure to empty it. Liquid manure is drawn into the vacuum tank through a 4- to 6-inch reinforced rubber hose.

Some agitation is accomplished by partly filling the tank with liquid manure, then forcing the liquid back to the storage gutter or tank.

For unloading, the tank is pressurized and the liquid manure is spread on the land. No manure passes through the pump, so it will not freeze. There are no moving parts in contact with the manure except the discharge valve, which gives minimum problems from freezing. These units cost $1400 to $2300 and are a practical method of emptying gutters and spreading liquid manure. It is difficult to agitate and empty large, square tanks with this equipment.

Chopper pump – This pump is more satisfactory than a vacuum pump for agitating and emptying large storage tanks.

A chopper pump can be mounted on a tractor with a 3-point hitch and driven by a power take-off. It can also be mounted on a trailer or on the top of the manure storage tank and driven by a separate motor or p.t.o. A chopper revolves at high speed below the intake of the pump, cutting up solids, including a small amount of bedding. The liquid manure circulates at high volume and high velocity in the tank, providing good agitation. The recirculating nozzle can be adjusted to agitate manure in all parts of the tank. After agitation, the manure is pumped into a spreader tank. These tanks are p.t.o.-driven with an áuger in the bottom and an impeller on the back

Figure 23. Trailer-mounted vacuum tanker.

for spreading. Spreader tanks cost about $1500. Chopper pumps also cost about $1500.

Applying liquid manure to the land

Liquid manure is transported to the field in a tank, then emptied by gravity, pressure, or auger and impeller.

When using a tank that empties by gravity, a splash disc will help in spreading, but the manure will still be too thick for satisfactory results. A tank that is emptied by pressure or impeller can be adjusted to spread the manure at the desired rate. For best fertilization, about 1,000 to 2,000 gallons per acre should be applied. Estimated fertilizer value of the manure, after deducting cost of storing and spreading, is between $0.50 and $1.00 per hog marketed. Care should be taken not to spread liquid manure on frozen ground in or near a drainage channel for

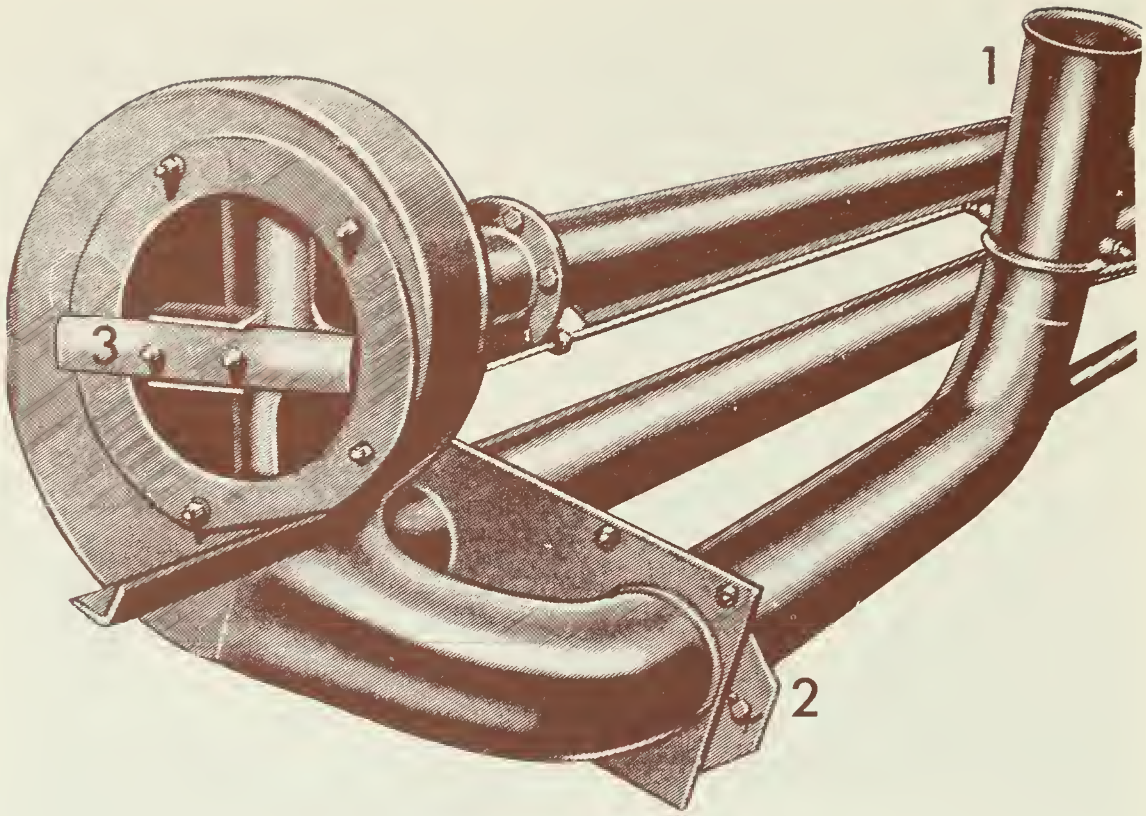

Figure 24. Chopper pump. Height of discharge spout (1) may be raised to 30 in. Adjustable deflector gives additional height or depth. Diverter valve (2) in position to agitate pit. Straw and solids are chopped to bits by rotary cutter (3) before going through pump.

Figure 25. Spreading liquid manure.

pollution control. Where the odor created by spreading liquid manure is objectionable, use a soil injection system. These systems place the liquid manure below the soil surface.