Management and Housing for Confinement Swine Production

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By

A. H. Jensen, B. G. Harmon, G. R. Carlisle
DEPARTMENT OF ANIMAL SCIENCE

A. J. Muehling
DEPARTMENT OF AGRICULTURAL ENGINEERING

The recommendations in this circular are based upon research data dealing with the breeding, housing and equipment, waste management, and feeding of swine. When specific measurements were not available, experience and observation were used as bases for suggested practices.

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SWINE PRODUCTION IS AN IMPORTANT PART of the Illinois economy. Income from the sale of swine represents about 20 percent of the total cash farm income in the state. During the last two decades, Illinois producers have made dramatic changes in swine housing and management and in the type and quality of hog produced. Although the total number of swine produced and marketed has changed relatively little during this period, the number of farms from which swine have been sold has decreased about 62 percent:

1949	133,000 farms
1954	98,000 farms
1959	95,000 farms
1964	66,000 farms
1969	51,000 farms

As individual enterprises have increased in productive capacity, the trend toward confinement rearing of swine has accelerated. Confinement (defined as any system that confines animals to non-dirt-floor housing units) has resulted in a concentration of large numbers of animals in small areas, and has generated new and more exacting demands on management.

The move to confinement production units has been stimulated by the high cost and limited availability of labor, increased land values and economically competitive alternative uses, advantage potential for mechanization and automation, volume production, environmental control, nutritional knowledge, closer management supervision and observation of animals, and operator comfort and convenience. Although it would be difficult to place a dollar value on "operator comfort and convenience," it may well be the most important consideration. Confinement can also be advantageous for disease control, since it allows isolation from rodents, wildlife, and birds that may be disease carriers.

The potential disadvantages of confinement as compared with pasture or field rearing include high investment, the problem of manure handling and disposal, and the possible concentration of serious disease problems. The Illinois producer has demonstrated that intensive rearing systems can be successful and profitable. Management includes all those decisions necessary for the best possible environment and operational efficiency. Excellent management has been the key to success.

Breeding Program

Individual animals selected for breeding should possess the genetic makeup necessary for production of a high-quality, marketable product. The traits emphasized in selection programs must be measured objectively. These traits should be economically important, moderate to high in heritability, and variable among animals being considered for herd replacements. Litter size, growth rate, feed efficiency, and carcass quality are economically important traits. With the exception of litter size, these traits are intermediate to high in heritability.

The extent to which change can be made by selection is limited by the heritability of the trait and the variation in the population from which replacement animals are selected. For example, the heritability of litter size is low, and the number of pigs farrowed and weaned is determined largely by management and environment. Backfat thickness, on the other hand, is highly heritable, and rapid change in the amount of backfat in succeeding generations can be made by selecting animals on the basis of live-backfat probe. Some average heritability estimates are shown below.

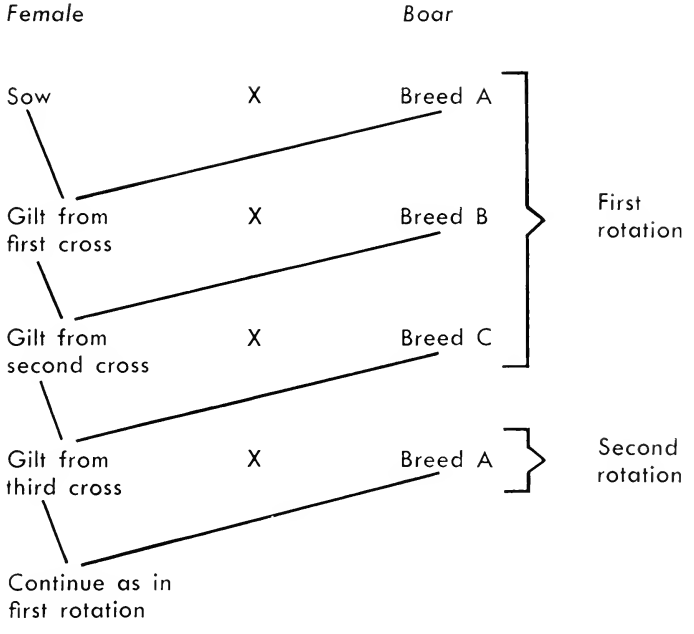
Trait	*Percent heritable*
Low heritability	
Number of pigs farrowed	15
Number of pigs weaned	12
Litter weight at weaning	17
Intermediate heritability	
Growth rate (weaning to 200 pounds)	29
Weight at five months	30
Feed efficiency	31
High heritability	
Carcass length	59
Loin eye area	48
Backfat thickness	49
Percent ham	58

A swine herd improves most rapidly when the number of traits considered in a selection program are kept to a minimum. The potential for improvement is greatest for the structural traits and next greatest for growth rate and feed efficiency. These traits should be emphasized in selecting replacement animals. Although litter size is economically important, the opportunity for improvement in this trait lies more in following a sound crossbreeding program than in emphasizing litter size in selecting replacement animals.

The commercial swine producer should follow a systematic crossbreeding program. The primary production advantage to crossbreeding is the use of the crossbred dam. The crossbred dam usually farrows and weans more pigs than the non-crossbred dam, and crossbred pigs are usually more vigorous and gain more rapidly than non-crossbred pigs. The choice of breeds should be based on the proved production traits of litter size, rate and efficiency of gain, meatiness, and structural ruggedness suited to maximum performance in confinement.

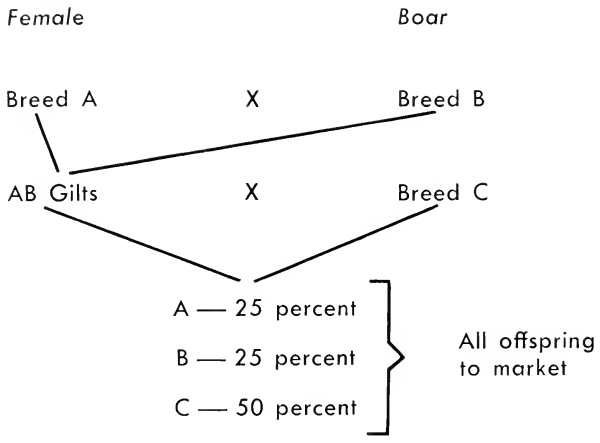
A three-breed rotation crossbreeding program produces greater hybrid vigor than a two-breed cross. A four-breed program theoretically has hybrid vigor advantage, but it also introduces extra management demands, since it may be difficult to find topflight boars of four breeds.

An example of a three-breed rotation crossbreeding program is shown below.



The three-breed program may be modified by using two specific breeds to produce gilts and a third breed for the boar. In this system, a breed consistently holds a position in a cross where it can contribute its best

characteristics. It also enhances maximum uniformity of offspring and market animals. An example is shown below.



Another breeding system includes new breeds of swine based on crossbred foundations. The various breeding lines within hybrid groups are rotated in breeding systems just as with individual purebred breeds.

Selection of Boars

Since producers usually select replacement gilts from their own herds, most of the genetic improvement will result from purchased boars. (Approximately 94 percent of the genes in any herd come from the boars used in the last four generations.)

To select boars effectively, you need to know the average level of performance (in the traits you wish to emphasize) of the herd from which the boar comes and the boar's own record. After the first two or three crosses, the rate of change depends upon the rate of progress in the herd from which the sires are selected. Boars tend to have genetic potential that is somewhere between their own performance and the average of the population from which they come. For example, in the case of two boars with identical records, one from a superior herd and one from an average herd, the boar from the superior herd will usually bring about the greatest improvement.

The selected boar should be superior in the traits that need to be emphasized. He should reach 200 pounds at least 20 percent sooner and

have at least a one-third larger loin eye than the herd average. The carcasses of littermates at 200 pounds should be a minimum of 29½ inches long and have at least one-fourth less backfat and one-fourth larger loin eye than the herd average. Be sure that the boars you purchase are from herds that are in a complete testing program.

Selection of Gilts

If you select boars carefully, the selection of gilts can be relatively simple. The following steps are suggested:

1. Ear notch (at birth or before litters are mixed) the pigs in big litters of uniform pigs that are free of inherited defects (Figure 1).

2. Before any market animals are sold, sort out the fastest gaining ear-notched gilts to consider for herd replacements.

3. Select gilts that seem to show the desired frame and length, are sound in their feet and legs, walk wide front and rear, have at least 12 good teats, and possess adequate muscle (as shown by a minimum of backfat) and natural thickness over their top and loin. A few gilts should be probed or sonorayed to provide an indication of the herd carcass quality.

Gilts that are narrow-chested and narrow-topped, or are short-legged and extremely muscular through their hams usually should not be retained as replacement stock.

Housing and Equipment

Both housing and management greatly affect swine performance. Management ultimately determines the use of available facilities. Housing units must provide at least the following: (1) a suitable environment for the pig: (2) minimal requirements for routine labor; and (3) a comfortable environment and convenient arrangements for the herdsman.

Slotted Floors

Before the introduction of slotted floors, manure was removed from confinement units by scraping (either by hand or through the use of tractor scrapers), water pressure, gutter-cleaner equipment, and various combinations of these. The labor required and the volume of material handled discouraged many producers from using confinement units.

The use of slotted floors has probably accelerated the trend toward confinement more than any other single development. Slotted floors consist of slats or other flooring materials with openings through which ma-

EAR-NOTCHING SYSTEM

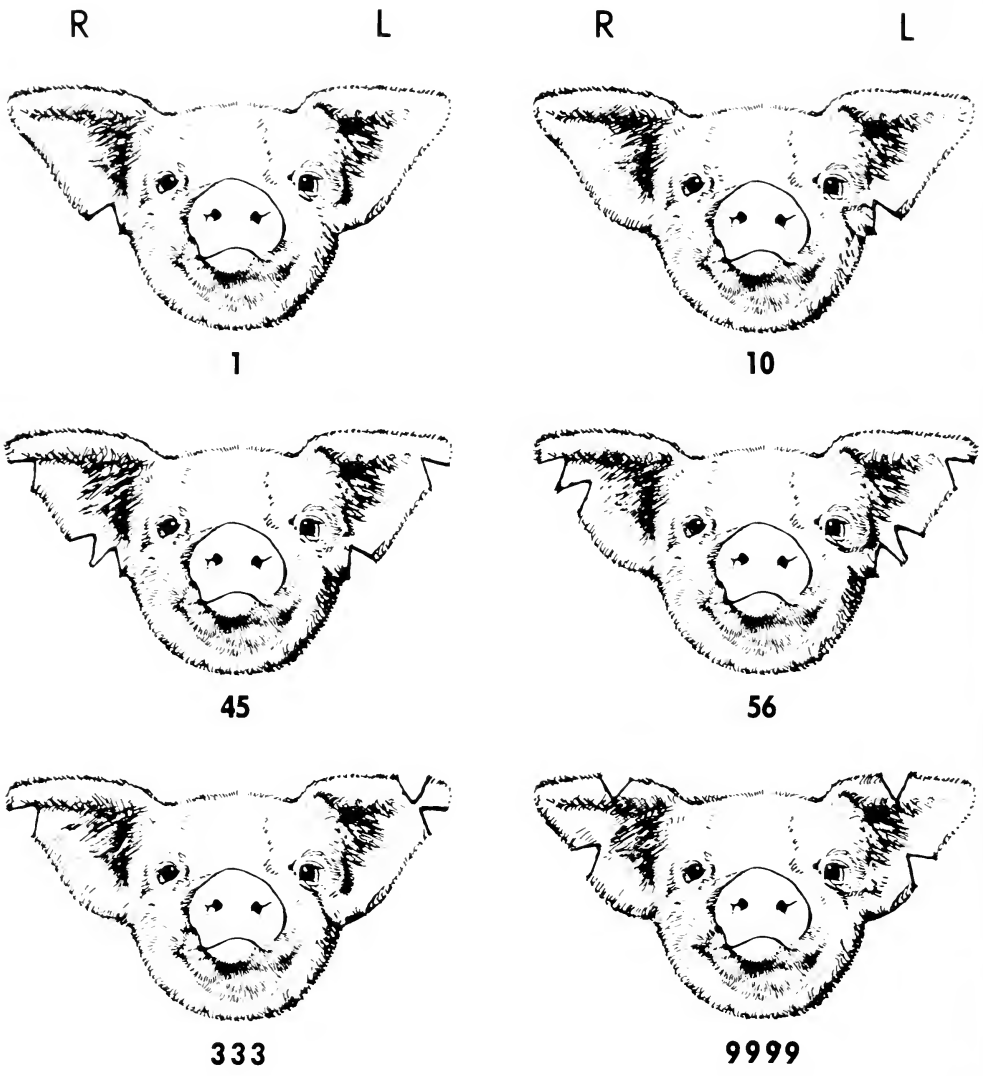


Figure 1. A notch next to the head on the lower right ear equals 1; a notch near the tip equals 3; and a notch midway between the head and the tip equals 9. The numbers are read from the top of the right ear clockwise as you face the pig. The last digit represents the individual pig within the litter. For example, the pig in the upper righthand corner is pig 0 in litter 10; the pig in the lower righthand corner is pig 9 in litter 9,990.

nure may drop or be trampled. There are two types of slotted floors -- partially slotted and totally slotted.

The main advantages of slotted floors are that they eliminate daily cleaning of pens and the use of bedding (assuming that necessary warmth is provided), and that they increase the sanitation potential because of cleaner pens and pigs. Research has shown that up to 90 percent of the labor required for the cleaning of solid floors could be eliminated by the use of totally slotted floors.

Carefully select the kind, size, and design of slats or slotted material. Concrete is the most durable and is easily cleaned. Soft woods are unsatisfactory because of rapid wear and warping. Pigs also chew through unprotected soft wood slats and boards. Do not use materials that become very slippery when wet or that have rough or sharp edges or other characteristics that might injure the pigs, especially their feet and legs. The slat surface should be smooth. Expanded metal, concrete or various metal grates, and concrete, wood, steel, or aluminum slats have been used. Some plastic materials are also available.

In general, the larger the animal, the wider the slats that can be used without sacrificing cleaning efficiency. Small pigs are less efficient than large pigs in working waste material through the slots. For this reason, narrower slats are more desirable for small pigs. Spacings should be in proportion to the width of the slats.

Suggested combinations for a totally slotted floor are shown below.

Housing unit	*Slat width*	*Spacing between slats*[a]
	(inches)	
Farrowing[b]	3-5	3/8 - 1/2
Nursery[b]	3-5	1
	1-2	1/2
Growing-finishing and gestation	7	1 1/4
	4-6	1-1 1/4

[a] A wider space adjacent to the partition or wall will reduce buildup of manure along the back or sides of the pen. One-inch slots in the rear 18 inches of the farrowing crate area will improve cleaning efficiency.

[b] No. 9-11 gauge, 3/4-inch, flattened, expanded, and galvanized metal is excellent for the front and rear of the farrowing crate floor and in the nursery.

In a study of growing-finishing pigs at the University of Illinois, the adverse effects of one-inch spacing with 1¼-inch slats became increasingly evident as the animals became heavier. By the time the pigs weighed 75

pounds, their feet and legs were sore. With increasing weight, the animals became reluctant to move about, and voluntary feed intake was markedly reduced. The various combinations of slat widths and spacings used are shown below.

Type of floor	Slat spacing (inches)	Pig weights (pounds)		Average daily gain (pounds)
		Initial	Final	
Solid concrete	..	40	200	1.42
Concrete slats (5″ wide)	1	41	205	1.45
Wood slats (4″ wide)	1	41	199	1.40
Wood slats (1¼″ wide)	½	40	204	1.45
Wood slats (1¼″ wide)	1	40	170	1.15

Variable spacings as a result of warping or careless installation, insecurely fastened slats, and uneven heights of slats also have an adverse effect on the behavior of animals on completely slotted floors. On partially slotted floors, however, the wider spacing with narrow slats did not measurably affect pig performance because the animals spent only a fraction of their time on the slat sections.

The potential advantages of slotted floors can only be realized under good management and proper use. Greater environmental control is required with totally slotted than with partially slotted or solid floors.

Breeding and Gestation Unit

Growing-finishing unit designs can be modified to provide excellent housing for breeding and gestating animals. It is especially critical that floor material and design allow for the physical comfort of the animal. Uncomfortable conditions discourage breeding aggressiveness of the male, cause reluctant behavior of the female, and result in unsatisfactory performance. Provide separate pens for boars, gilts, and older sows, and an area for breeding.

Farrowing Unit

Since the newborn pig is extremely sensitive to cold and the sow is susceptible to high temperatures, the farrowing unit must be designed so that both animals can be comfortable. Supplemental heat (overhead or in-floor) is usually required in the baby pig sleeping areas (see page 19).

The floor surface should be smooth to minimize skin abrasion to nursing pigs. To drain liquids away from the pigs, slope solid floors about ½ inch per foot from the sleeping area to both the front and rear of the farrowing crate. In partially slotted floors, the solid area should be finished so that liquids will not be retained.

Slotted floors should be designed to minimize injury to the sow and litter while maximizing cleaning efficiency. In completely slotted pens, slats should lay parallel rather than perpendicular to the sow. The slat edge provides footing for the sow in getting up and down and for the nursing pigs. The spacing between slats should be a uniform ⅜ to ½ inch so that small pigs do not get their legs caught between the slats. Wider slots in the rear of the crate area facilitate efficient cleaning, but these must be filled or covered at farrowing time and remain covered until pigs are mobile enough to cope with them (Figure 2).

Expanded metal should be installed so that the length of the diamond-shaped opening is parallel to the sow. This arrangement will minimize the possibility of injury to nipples (Figure 3).

Nursery Unit

The nursery unit may be designed for sows and litters removed from the farrowing unit when the litters are a few days to two weeks old, or it may be designed for baby pigs only.

For the sow and litter unit, place two or three sows and their litters in one pen. A partially slotted floor is recommended, with a separate baby-pig brooder area at the upper end of the pen. Each sow and litter will need 40 square feet of floor space. Floors should be kept clean and dry. Wet, slippery floors increase the chances of injury.

A nursery unit for pigs from the day of weaning until they weigh 50 to 60 pounds must provide a comfortable environment (see page 19). This environment can be provided either by entire-building heat or by heated localized areas in each pen. Room temperature can be somewhat lower in a partially slotted floor unit than in a totally slotted one, since the pigs will have a solid-floor sleeping area (Figure 4).

Buildings and ventilation systems must be designed so that the pigs will not be subject to drafts. Rough hair coats and excessive huddling indicate cold stress. It is particularly important to avoid drafts in a totally slotted floor nursery.

An overlay in the sleeping area during the adjustment-to-weaning period is beneficial. Room temperature can be decreased as the pigs increase in size. Totally slotted floors are preferred for maximum cleanliness and dryness.

No. 9-11 gauge, ¾-inch, flattened, and expanded metal flooring is unexcelled for cleaning efficiency and is not stressful to the pigs. It does require strong, rigid support, however, and it can be shortlived. Galvanizing will increase its useful life.

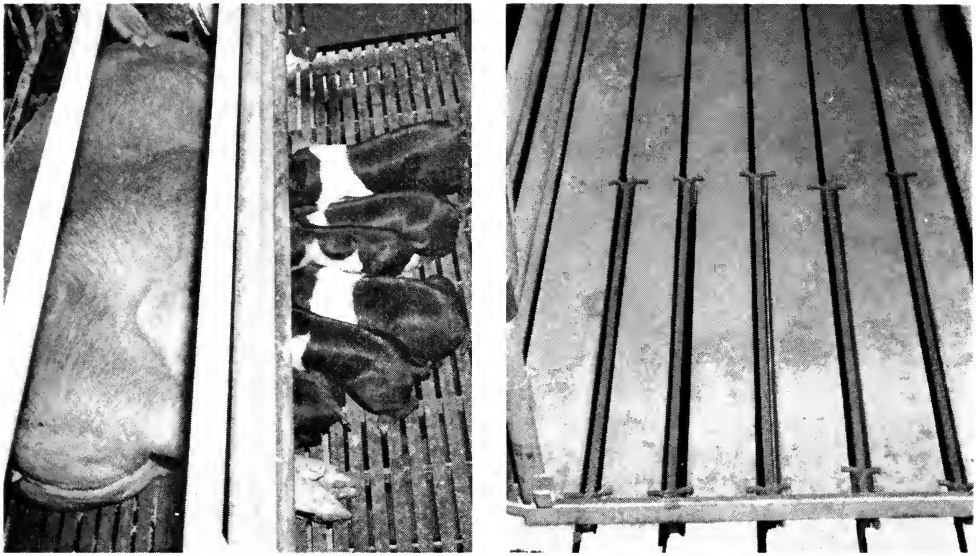


Figure 2. Totally slotted floors with steel slats (left) and concrete slats (right). The steel slats are 1 inch wide with ½-inch spacings between slats; the concrete slats are 3 inches wide with ½-inch spacings except at the rear of the pen, where spacings are wider (foreground). The iron rods are removed as soon as the pigs are old enough to cope with the wider openings.

Figure 3. A farrowing stall with No. 9-11 gauge, ¾-inch, flattened, and expanded metal flooring at front and rear. This flooring is easy to clean and comfortable for the pigs. Galvanizing increases its useful life.

Figure 4. A nursery unit with a partially slotted floor. The concrete portion of the floor slopes toward the expanded metal-covered gutter. Electric heating units are in the floor near the feeder end of the pen. In a nursery unit with a totally slotted floor, environmental control is more critical.

Specialized units can be designed for pigs removed from the dam two or three days after birth (or after piglets have suckled and ingested colostrum). Rigid control of environment, feeding, and management are essential. Devices are available for automated feeding of a liquid diet to individually caged pigs (Figure 5).

Colostrum-deprived pigs that are given adequate isolation and care can also be successfully reared, and have been used to establish Specific Pathogen Free or Minimal Disease herds. Superior management, environmental control, and continuous attention to minute detail are essential for the success of these programs.

Growing-Finishing Unit

Extremes of heat and cold decrease efficiency of production. The pig in a warm environment will eat less in an effort to minimize body heat production, while the pig in a cold environment will eat more to compensate for the extra energy used to maintain body temperature.

The responses of growing-finishing pigs to various winter and summer housing systems are shown below.

WINTER HOUSING	Enclosed[a]		Open-front[d]
	Heated[b]	Unheated[c]	
30-105 pounds			
Average temperature, degrees F.	71	50	21
Average daily gain, pounds	1.76	1.76	1.65
Average daily feed, pounds	3.33	3.61	3.96
Gain per 1,000 pounds of feed, pounds	522	488	416
105-240 pounds			
Average temperature, degrees F.	68	56	34
Average daily gain, pounds	1.80	1.80	2.00
Average daily feed, pounds	6.36	6.31	7.37
Gain per 1,000 pounds of feed, pounds	283	285	271

[a] Insulated, windowless wood-frame building with partially slotted floors.
[b] Gas-fired space heater used to maintain a minimum temperature of 70° F. during the growing period and 60° F. during the finishing period.
[c] No supplementary heat or bedding used.
[d] Concrete walls, open-front on southern exposure. Solid concrete floor, with wooden overlay plus straw provided in sleeping area.

SUMMER HOUSING	Open-front[a]	Dirt lots[b]
Space per pig, square feet	10	180
Average initial weight, pounds	99	96
Average final weight, pounds	200	194
Average daily gain, pounds	1.56	1.41
Average daily feed, pounds	5.15	5.21
Gain per 1,000 pounds of feed, pounds	303	271

[a] Four pens of 15 pigs each.
[b] Two lots of 30 pigs each.

Typical basic designs of buildings with partially and totally slotted floors are shown in Figures 6 and 7. With totally slotted floors, labor is minimized and pens and animals remain clean (Figure 8). The solid portion of partially slotted floors may be covered with manure during hot weather, since pigs benefit from evaporative cooling by lying on the wet floor.

Pigs do not have moist floor-sleeping areas on totally slotted floors, and supplementary cooling (evaporative, water spray, zone air cooling, etc.)

may be desirable. Research has shown that when equally comfortable environments are provided, growing-finishing pigs perform similarly on floors of varying degrees of slotted surface area.

When open-front building units are used, partially slotted floors all under roof are recommended. Heating elements in the floor of the sleeping area or radiant heat brooders above the floor will provide adequate warmth during cold weather. Bedding material should not be used if manure is stored and handled as a liquid.

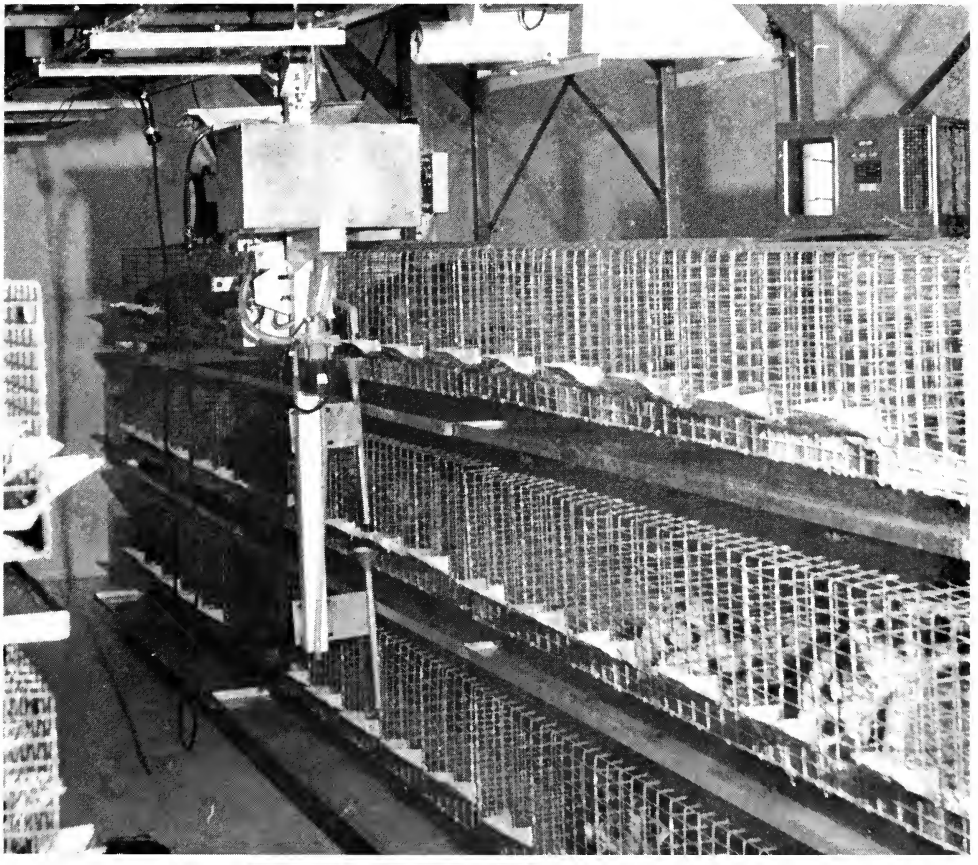


Figure 5. A mechanical unit designed for rearing individual pigs from a few hours after birth until they are three or four weeks old. This "automatic sow" is programmed to dispense specified amounts of feed at regular intervals.

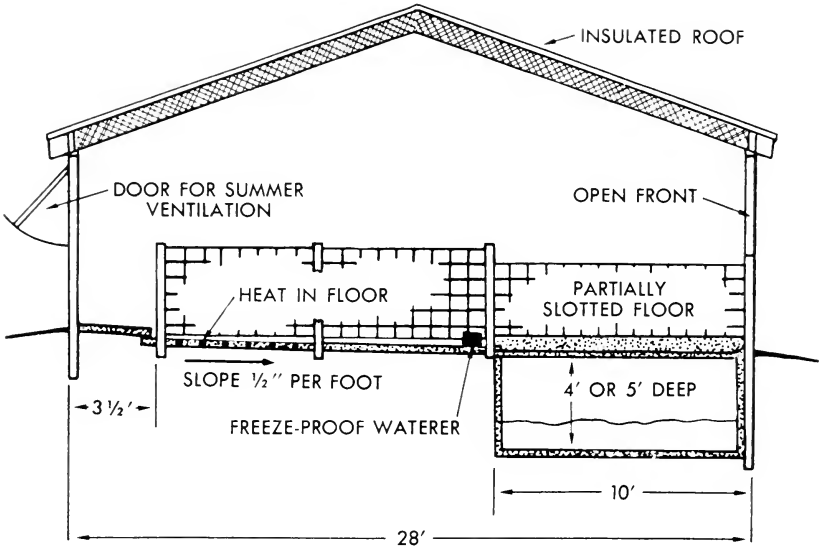


Figure 6. Growing-finishing or breeding herd unit with a partially slotted floor. In cold climates, mechanical ventilation would be added, and the building would be completely enclosed. Alternate designs could include a wide center gutter and a work aisle along each wall, or a gutter along each wall and a work aisle in the center of the building.

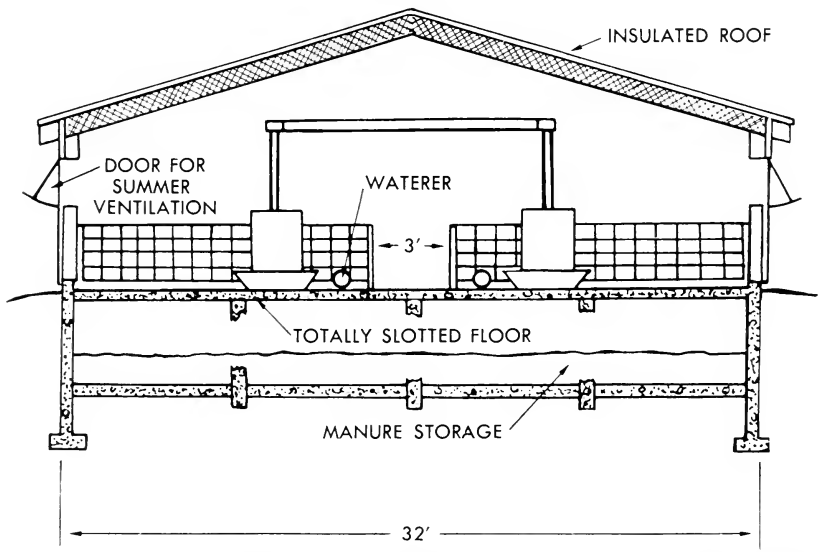


Figure 7. Growing-finishing or breeding herd unit with a totally slotted floor. This design eliminates the need for daily cleaning of floors.

Figure 8. In units with totally slotted floors, animals and floors remain clean. Feed flow must be carefully regulated to avoid waste.

Holding Unit

The holding unit should be suitable for taking care of "overflow" situations, and should include an isolation section for disease control. A totally slotted floor is recommended.

Ventilation, Heating, and Cooling

The amount of ventilation needed varies with the season, size of animal, and density of animal production. Probably no one ventilation system will be adequate for both summer and winter temperature extremes. The main purpose of ventilation during the winter is to remove water moisture

before it condenses on cold surface areas. During the summer, ventilation is used to remove the heat generated by the animals from the building.

Adequate ventilation is essential *during all seasons* to minimize odor buildup. A ventilation system is inadequate if it does not maintain a uniform environment throughout the animal areas. To minimize the amount of mechanical ventilation equipment needed, design buildings so that wall panels can be opened for natural air movement in the summer. Minimum ventilation rates are given below.

	Ventilation rate, CFM[a]	
	Winter	*Summer*
Farrowing unit (sow and litter)	80	350
Nursery unit (30- to 50-pound pig)	20	100
Growing-finishing unit (50- to 225-pound pig)	35	150
Breeding and gestation unit (gilt, sow, or boar)	50	350

[a] Cubic feet per minute. These values are considered minimum rates under normal conditions.

For the ventilation system to function properly, it is necessary to have good insulation. Insulation reduces heat losses in the winter and heat buildup in the summer and helps prevent condensation. Insulation values of different materials vary widely. For example, a three-inch thickness of bat insulation has a value almost nine times that of a poured concrete wall six inches thick.

The principal method of preventing heat stress during warm periods is to increase air movement. Piping cooled air to the sow's head in farrowing units will alleviate the stress of high ambient temperature. A window-type air conditioning unit (one-ton capacity) can supply sufficient cooled air for 10 sows in farrowing stalls.

Evaporative cooling is effective in areas of relatively low humidity. Water sprinklers, thermostatically controlled to prevent unnecessary use of water, are also effective. Pigs on totally slotted floors may be stressed more by heat than pigs on partially slotted or solid concrete floors, since they cannot maintain a wet surface area and benefit from evaporative cooling.

Recommended ambient temperatures for maximum efficiency of performance are shown on page 19. These temperatures are at animal level. Watch both the room thermometer and the animals — especially young pigs. If the pigs are huddling and piling on one another, they are uncomfortable regardless of the thermometer reading.

	Degrees F.
Pigs	
Nursing or weaned (up to 10 pounds)	90
10-25 pounds	80
25-50 pounds	75
50-100 pounds	70
100-150 pounds	65
150-200 pounds	60
Gestating gilts, sows, and boars	
With bedding	50
Without bedding or on slotted floors	60
Lactating sows	
With bedding	60
Without bedding or on slotted floors	70-75

Waste Disposal

Storage, removal, and disposition of wastes must be integral parts of any confinement system. The total amount of excreta (feces and urine per day) is about 7.7 pounds per 100-pound hog. This is equivalent to a volume of one gallon or ⅛ cubic feet of space. Diet, method of feeding, amount of wasted water, and amount of cleaning water used will affect total volume.

The actual fertilizer value of a ton of liquid hog manure will vary considerably. Average equivalent values are about 0.7 percent nitrogen (N), 0.4 percent phosphoric acid (P_2O_5), and 0.4 percent potash (K_2O). The real or dollar value will depend upon the cost of commercial fertilizer, the cost of removal and hauling to the land, availability of the land-disposal area, storage capacity suited to removal schedules, and total volume of production.

Waste management includes methods of handling and treating and provision for disposal. Disposal systems currently used in confinement swine production usually involve one or more of the following:

1. Regular cleaning, hauling, and disposal on land.
2. Retention under the slotted floor, with hauling and disposal on land as needed or when uncropped land is available. When land is not available, a lagoon is necessary.
3. Lagoons as final disposal area.

With disposal of wastes on the land, injection of the liquid manure into the soil is recommended to prevent odor and runoff problems.

Biological activity in liquid manure is continuous. In undisturbed liquid wastes stored in buildings, an anaerobic state exists, and microbial me-

tabolism in this medium produces ammonia, carbon dioxide, hydrogen sulfide, and methane gases (Table 1). A large group of trace organic compounds are also produced.

In addition to being odorous, hydrogen sulfide and ammonia can prove toxic at certain levels. Insidious irritation or toxic effects may result from prolonged exposure. For this reason, adequate ventilation is essential to prevent gas buildup. When liquid manure has been stored for a considerable time, vigorous mixing or agitation can release dangerous and even lethal concentrations of hydrogen sulfide. When agitating or pumping slurry from anaerobic storage, be sure that ventilation is sufficient to remove released gases.

The oxidation-ditch system of liquid-manure treatment essentially eliminates odor from the waste materials because of aerobic (require oxygen) bacteria. The principal products of these bacteria are carbon dioxide and water. Odors in the building can be markedly reduced and biological oxidation of the organic matter increased. Design recommendations for in-the-building oxidation ditches are given below.

	Sow and litter	*Growing pig*	*Finishing pig*
Weight, pounds per unit	375	65	150
Daily BOD_5, pounds per unit[a]	.79	.14	.32
Daily required oxygenation capacity, pounds per unit[b]	1.58	.28	.62
Number of animals per foot of rotor, units per foot[c]	16	91	41
Ditch volume, cubic feet per unit[d]	23.70	4.20	9.60
Daily requirement per unit, kilowatt hours (KWH)[e]	.83	.15	.33
Daily KWH cost per unit, dollars[f]	1.66	.30	.66

[a] BOD = biochemical oxygen demand. These values are based on average composition and quantity of swine excreta.
[b] Twice the daily BOD_5.
[c] Based on 25.5 pounds of oxygen per foot of rotor per day.
[d] Based on 30 cubic feet per pound of daily BOD_5.
[e] Based on 1.9 pounds of oxygen per KWH.
[f] Based on electricity at two cents per KWH.

Open lagoons can also be aerated. With mechanical aeration, one cubic foot of volume is required for each pound of live hog. For natural aerobic conditions, a minimum of eight cubic feet of volume is required per pound of hog, and the pond should be from three to five feet deep.

The system of manure handling, storage, and disposal should not contribute to pollution of air and water sources. Before constructing new

facilities, consult state regulatory agencies for proper guidelines and approval of design.

Table 1. — Characteristics of Certain Gases Produced by Microorganisms in Stored Liquid Swine Wastes

Gas	Specific gravity[a]	Odor[b]	Color	Physiological effects[c]
Ammonia (NH_3)	.58	Pungent	None	Irritant, especially to respiratory system
Carbon Dioxide (CO_2)	1.53	None	None	Asphyxiant
Hydrogen Sulfide (H_2S)[d]	1.19	"Spoiled egg"	None	Irritant, toxin
Methane (CH_4)	.58	None	None	Mild asphyxiant

[a] Air has a value of 1. A number less than 1 means lighter than air, more than 1 means heavier than air.
[b] Certain trace organic compounds such as amines, mercaptans, and skatols are usually present in a confinement unit, and may contribute to the total "odor load." These products, however, have not been defined with respect to tolerance levels in confinement units.
[c] Observed in adult human behavior.
[d] Produced from decomposition of organic wastes under anaerobic conditions.

Management Practices

Management is of major importance in all phases of production, but it is especially critical in the area of reproduction. The care and comfort of animals in confinement greatly affect total production efficiency. Recommendations for space allowances and the number of animals per pen in confinement swine housing are shown in Table 2. These recommendations are based on research results and management observations of intensive swine-rearing programs.

Boars

The boar should weigh 250 pounds or be at least eight months old when first used for breeding. Ruggedness and soundness are essential to withstand continuous confinement. It is poor practice to skimp on quality of boars or the number purchased. A boar that is overfat, sick, under stress of high ambient temperature, overworked, or mishandled (an impatient herdsman can ruin a good boar) will not perform satisfactorily.

Acquire the boar at least 30 days prior to the beginning of the breeding season. This period allows the boar to adjust to his new environment and gives you an opportunity to observe him for clinical signs of disease or other undesirable reactions. A few days before the breeding season,

Table 2. — Recommended Floor Space Per Animal Unit and Number of Animals Per Pen[a]

Animal unit	Weight (pounds)	Minimum space per animal unit (square feet)			Number of animals per pen
		Solid floor	Partially slotted floor	Slotted floor	
Sow and litter[b]	...	35[c]	35	35	...
Weaned pig	10– 25	4[d]	2.75	2.75	20–30
Growing pig	25– 40	6	3	3	20–30
	40–100	8	4	4	20–30
Finishing pig	100–150	10	6	6	10–15
	150–210	12	8(9)[e]	8(9)[e]	10–15
Breeding females					
Gilt	250–300	15	12	12	12–15
Sow	300–500	18	15	15	10–12
Gestating females[f]					
Gilt	250–400	17	14	14	12–15
Sow	300–500	18	15	15	12–15
Boars	...	70	50	50	1–3[g]

[a] Recommendations are based on research results and management observations of intensive swine-rearing programs.
[b] The farrowing stall area is usually 5 feet by 7 feet. The stall itself is 22 to 24 inches wide and 6½ to 7 feet long.
[c] The floor should be sloped both to front and rear of the farrowing stall to facilitate drainage away from the pigs.
[d] The floor in solid-floor pens should slope about ½ inch per foot. A concrete floor, whether solid or slats, should be smoothed with a steel trowel when poured.
[e] The numbers in parentheses indicate the suggested space allowances during very hot weather.
[f] Individual pens should be about 22 inches wide and 6 feet long for gilts and 24 inches wide and 7 feet long for sows. Tethered animals require essentially the same amount of space.
[g] If possible, pen boars individually. When is is necessary to have more than one boar in a pen, put the boars together when they are young. Mixing mature boars that are strangers to one another may result in fighting and subsequent injury.

test each boar by mating him to a sow or market gilt. It is a good practice to have an extra boar as a replacement for an injured or nonworking boar.

The advantages of pen-mating over hand-mating are (1) less herdsmen time and managerial skill are required; (2) boars detect females at receptive periods of the estrus; and (3) boars may work better alone. But hand-mating is preferable. The increased time and labor required in hand-mating are offset by the more efficient management possible because farrowing dates are known.

Hand-mating and mating twice during the estrus period (at least six hours between matings) will usually result in a higher conception rate and

more pigs per litter at farrowing. With hand-mating, more females can be bred per boar, breeding dates can be accurately recorded, the number of services per animal can be controlled, and specific matings can be scheduled.

The number of females a boar services during a given breeding season may vary greatly. Suggested guidelines are shown below. These numbers are considered maximum for a single mating per female, and it is assumed that breedings will occur over the entire breeding season.

	Pen-Mating		*Hand-Mating*	
Season	*Young boar*	*Mature boar*	*Young boar*	*Mature boar*
21 days...	10 females	15 females	15 females	30 females
42 days...	20 females	30 females	25 females	40 females

The following suggested practices will enhance breeding efficiency:

1. In hand-mating, take the female to a separate aisle or pen area where the boar is accustomed to breeding. When possible, breed the female to two boars six to 12 hours apart.
2. Use a breeding crate to minimize the effect of differences in animal size.
3. In pen-mating, alternate boars daily to prevent overworking and favoritism.
4. Avoid slippery floors, uneven or rough surfaces, etc. that might discourage normal behavior of the breeding animals or cause injury.
5. Do not mix boars — they may injure each other fighting.
6. Feed the boars after the service.
7. Do not use boars for at least five weeks following a period of high body temperature.
8. In hot weather, breed during the cool of the day.

Gilts and Sows

Gilts should be eight months old or weigh 250 pounds before they are bred. Overt signs of estrus in young gilts may be less obvious and of shorter duration in confinement than in pasture environments. There is some evidence that moving gilts from one location to another (between buildings or even within a building), the close proximity of boars, and mixing of animal groups will in many cases precipitate onset of estrus.

From a management viewpoint, however, mixing animals of breeding age is not desirable. The number of gilts or sows per group should be relatively small (10 to 15) to minimize competition and irritation. If

breeding problems persist, it may be desirable to have the gilts in outside lots during the breeding season.

Estrus Control and Artificial Insemination

Control of estrus allows precise scheduling of breeding and farrowing. Both natural and artificial methods can be used. The natural method is through controlled weaning. Estrus will occur in the sow within four to seven days after her litter is weaned. When several litters are weaned on the same day, all of the sows can usually be bred seven to 10 days later.

If litters are weaned under three weeks of age, the conception rate at first estrus will be lower than if weaning occurred at four weeks or later. There is some evidence that conception rate and litter size are improved if sows are not mixed until after they are bred following three-week weaning. Estrus and ovulation have been induced experimentally by careful administration of hormonal substances. If these compounds are used incorrectly, however, they may be ineffective or cause an adverse response.

Artificial insemination is not currently in wide use, but it may become popular when estrus control methods are perfected. Successful detection of estrus and correct handling of the semen are essential for best results. Sows and gilts should be checked twice daily for estrus. If the female will stand when pressure is applied to her back, insemination can usually be performed. The female should be inseminated as soon as possible after she is checked. A second service about 12 hours later will insure maximum conception rate and litter size.

Research indicates that mixed semen from different boars is superior to semen from one boar. Fresh semen should be used within eight hours after collecting, since fertility declines rapidly after this period.

Gestation Period

During gestation, keep animals in small groups (12 to 15 animals) or pen them individually or tether them either by neck collar or by belt (Figure 9). Maintain a comfortable, clean environment and provide adequate diets. First litter gilts should gain about 70 pounds during gestation, and sows should gain about 40 pounds. Follow disease-prevention management practices discussed on pages 29-31.

Farrowing and Lactation Periods

Comfortable environments are essential for the sow as well as for the newborn pigs. Avoid unnecessary disturbance and provide assistance if

needed. Water should be available at all times. After farrowing is complete, remove and incinerate the afterbirth.

Loss in baby pigs is usually greatest during the first few hours after birth. Many pigs die at this time from stress caused by chilling. Since baby pigs need an ambient temperature of 90° F. for comfort, supplemental heat must be provided in the sleeping area. Overhead heat (provided by heat lamps or flameless gas radiant heaters) aids in warming and drying the pigs. They will detect the overhead heat more quickly than the heat in the floor. The light of the heat lamp serves to attract the pig to the desired sleeping area.

Heating elements in the floor keep the floor dry and warm and minimize the conduction of body heat to the floor. Temperatures can be lowered as pigs increase in size. Avoid draft conditions.

Clipping the needle teeth soon after birth will reduce potential damage to the sow's udder and prevent injury from fighting. Tying off the navel cord and daubing with tincture of iodine solution (2 percent iodine in a 40- to 70-percent alcohol solution) will reduce the possibility of navel infections. Remove the tail about one-half inch from the base to prevent tail biting later. Litter identification is necessary for effective record-keeping. Ear notching is the most reliable method (see Figure 1).

Figure 9. Tethering animals is usually less expensive than providing individual pens. The neck collar (left) is most frequently used, but some swine producers prefer the belt tether (right).

Injectable or oral iron preparations will prevent iron-deficiency anemia. Iron should be administered by the time the pigs are five days old.

Male pigs not retained for breeding should be castrated before they are 14 days old. As the pig becomes older and heavier, the shock of castration becomes greater.

Feed a fortified 16-percent protein corn-soybean meal diet or equivalent (Table 3). A lactating sow can be self-fed, fed a specific amount per day, or fed a basic amount (4 pounds) plus an allowance (¾ pound) for each nursing pig. Hand-feeding offers the advantage of closer observation of each sow.

To get the pigs to eat more dry feed, provide them with a palatable creep feed by the time they are two weeks old. Use a small pan or trough for the first few days. Locate the creep feeder close to the sow feeder so that the pigs will be encouraged to eat.

Under farm conditions, a healthy 12-pound pig can be weaned if proper environment, management, and nutrition are provided. Weaning pigs on a weight basis insures uniform groups of weaned pigs, and the lighter pigs remaining with the dam have less nursing competition. When an entire litter is weaned, it may be easier for the pigs to adapt to weaning if left in the farrowing crate for a few days.

Pigs should be weaned by six weeks of age. Some advantages for weaning at younger ages are as follows:

1. Less labor.
2. More efficient use of space because more litters can be farrowed per year.
3. Reduced total sow feed.
4. Sows can be rebred or sold sooner after farrowing.
5. Sows lose less weight during lactation.
6. The pigs have a more uniform environment.
7. Disease transmission from the dam to her offspring is minimized.

Superb management and excellent facilities are essential for pigs weaned before they are three weeks of age.

Growing-Finishing Period

Place pigs of uniform size in a group. Usually they will perform better than groups of pigs of varying sizes. Overcrowding or unnecessary mixing of groups also reduces performance efficiency. You can provide increased space for heavier pigs by reducing the number of animals in a pen or by moving the group to a larger pen. Feed appropriate corn-soybean meal or equivalent diets to insure adequate nutrition (Table 3).

Table 3. — Sample Diets for Swine of Various Ages

Ingredients	Illinois Creep Ration 20 (5- to 30-pound suckling pigs)	Illinois Starter Ration 20 (10- to 30-pound weaned pigs)	Illinois Ration 16 (30- to 120-pound pigs and lactating stock)	Illinois Ration 14 (120- to 200-pound pigs)	Illinois Ration 12 (gestating stock)
Protein content, percent	20	20	16	14	12
Ground yellow corn, pounds	510	320	1,545	1,660	1,745
Soybean meal, 44-percent, pounds[a]	600	500	400	300	200
Dried whey, sweet 70-percent lactose, pounds	300	500	...	...	...
Dried skim milk, pounds	100	100	...	...	...
Sugar, cane or corn, pounds	200	200	...	...	...
Rolled oats or oat groats, pounds	200	290	...	...	...
Animal fat, pounds	40	40	...	...	...
Trace-mineralized salt, pounds[b]	10	10	10	10	10
Ground limestone, pounds[c]	20	20	20	10	20
Dicalcium phosphate or equivalent, pounds[d]	20	20	25	20	25
Vitamin additions					
Vitamin A, I.U.	3,000,000	3,000,000	3,000,000	2,000,000	5,000,000
Vitamin D, I.U.	600,000	600,000	300,000	150,000	300,000
Vitamin E, I.U.	20,000	20,000	10,000	10,000	20,000
Riboflavin, grams	2	2	1	.5	.5
Niacin, grams	30	30	15	7.5	7.5
Pantothenic acid, grams	10	10	5	2.5	2.5
Choline, grams	200	200	100	50	50
Vitamin B_{12}, milligrams	32	32	16	8	8
Antibiotics, grams[e]	+	+	+	+	...

[a] With 50-percent soybean meal, use 520 pounds in Illinois Creep Ration, 420 pounds in Illinois Starter, 360 pounds in Illinois 16, 260 pounds in Illinois 14, and 160 pounds in Illinois 12. Corn values should be adjusted accordingly.
[b] May be added as ordinary salt and trace-mineral mixture. If the trace-mineralized salt contains less than 0.5 percent zinc, add 0.1 pound of zinc carbonate per ton of complete feed.
[c] Assumed 38 percent calcium.
[d] Assumed 28 percent calcium and 18 percent phosphorus for dicalcium phosphate.
[e] Use the appropriate antibiotic. Follow feeding instructions on the label.

Feeding Methods

Self-Feeding

For maximum daily gain, allow the pig access to feed at all times. Regardless of the design of the feeder, feed wastage can occur. Keep the level of feed in the trough low. If the pigs can work agitators just enough to get the feed they want, their performance level will not be adversely affected. Lids over the feeder trough reduce wastage, since pigs tend to keep their heads under the raised lid while eating. Divider bars in the troughs prevent pigs from pushing feed out of the trough. One feeder hole should be provided for each four to six pigs.

On-Floor Feeding

On-floor feeding is particularly suited to controlled feeding of finishing swine or the breeding herd. Feeding in the sleeping area encourages cleanliness, since pigs are less inclined to dung where they eat. Feed wastage is reduced to a minimum when the animals do not have more feed available than they will consume at one eating. Even though automated, restricted feeding requires close attention because the daily feed intake of pigs will be affected by weather.

Liquid Feeding

Liquid feeding usually involves mixing predetermined amounts of feed and water prior to or at the time of feeding. When properly used, this method can practically eliminate feed dust in the feeding area and minimize wastage. Ratios of feed and water can be varied to produce a free-flowing liquid or a thick paste. In some cases, feed is automatically dropped into the water in the feed trough.

Interval Feeding

Interval feeding allows the animals access to a self-feeder at specified times (usually every second or third day) during gestation. The number of hours that the animals have access to the feeder should be related to their condition and the amount of feed they consume. It is important to feed on schedule so that they don't become restless. Interval-fed animals use feed somewhat less efficiently than those fed daily, but less labor is required. Reproductive performance is not significantly affected.

Water Provision

For maximum feed intake, pigs must have continuous access to water. Waterers should be appropriately designed for the age and size of the

pigs, and the water should be fresh, clean, and easily available. To prevent excess wastage and maintain dryer floor conditions (especially in gestation units), turn on the water for only a few hours a day.

For group-fed animals, one waterer unit should suffice for each 20 pigs. A waterer with two openings is adequate for 40 pigs if two pigs can drink at the same time. A watering system should supply at least two gallons of water per animal per day.

Herd Health

Sanitation

An effective sanitation program will prevent the development of many disease problems. The following suggestions are intended to emphasize the need for a regular cleaning program.

Clean and disinfect the farrowing unit. Use either a steam cleaner or a power sprayer. If you use a power sprayer, add an alkaline detergent to help with the cleaning. Hot lye water (one pound of lye to 30 gallons of water) is an excellent cleaning solution, but do not use on aluminum. Wear eye goggles and rubber gloves to avoid lye burns. Remove all dirt and foreign material. Rinse the cleaned surfaces with clean water to remove soaps or detergents, and apply an approved disinfectant.

Disinfectants have to make contact with the organisms to kill them. If the organisms are imbedded in the dirt or manure, contact is limited and the results may be unsatisfactory. Good disinfectants include certain quaternary ammonium compounds, phenol solutions, or hypochlorites. In general, these work best when used on warm surfaces.

A county extension adviser or a veterinarian can recommend specific disinfectants. Follow manufacturer's recommendations carefully.

Fumigation of hog buildings is considered an effective disinfecting procedure between pig crops, and is particularly recommended for the farrowing unit. The following steps are recommended after the building has been cleaned:

1. Tightly seal all doors and windows.
2. Maintain a room temperature of 65° F. or higher.
3. Moisten the floor with water about 15 minutes before fumigation.
4. Estimate the number of cubic feet of air space in the building (length × width × height).
5. Use one pound of formalin and one-half pound of potassium permanganate crystals (or other products of equivalent potency) for each 1,500 cubic feet of air space.

6. Place the crystals in a wide-bottomed container in the center of the building, pour in the formalin, and *leave the building immediately.* An alternative method is to heat crystalline formalin in an electric skillet to produce formaldehyde gas.

7. Close the building for at least eight hours and then air out for 12 to 24 hours before using.

Plan the production program so that the cleaned farrowing equipment can be idle at least a week before each farrowing season. These "sanitation breaks" will reduce the potential buildup of disease.

One week before the sow is due to farrow, she should be washed, sprayed with an approved insecticide, and moved to the clean farrowing quarters. Continue to feed the gestation diet until she farrows. Sows placed in farrowing units one to two weeks prior to farrow may develop an immunological response to the farrowing house environment. This response results in antibodies in the colostrum that protect the nursing pig.

Avoid contamination of clean sows. If the sows are hauled, use a clean vehicle. If they are driven between buildings, keep them on a solid walk or driveway.

Vaccination and worming, if necessary, should be performed four to eight weeks before farrow. Regular observation and treatment are essential to prevent buildup of external parasites (lice and mange) and internal parasites (ascardis, etc.).

Disease Control

Most hog diseases are more easily prevented than cured. The following practices will help prevent diseases:

1. Follow a good sanitation program.
2. Feed nutritionally adequate rations (see Table 3).
3. If warranted, immunize pigs against erysipelas and leptospirosis.
4. Provide enough space and equipment (see Table 2 for recommendations).
5. Blood test all breeding stock for brucellosis and leptospirosis at least once a year and discard reactors.
6. Maintain a closed herd whenever possible. When stock is purchased, isolate the animals for three weeks and observe carefully for signs of disease. Blood test for brucellosis and leptospirosis. Buy SPF breeding stock if possible. If this stock is not available, buy from breeders who have healthy herds and who minimize movement of hogs onto their farm.
7. Isolate the hog operations from the public. Keep outside persons or vehicles out of the hog pens, lots, or buildings.

Vaccination, castration, and weaning on the same day may unduly stress the young pig. These should be performed at separate times, allowing for a reasonable adjustment period after each. Keep fresh feed and water available at all times.

For maximum production efficiency, you must be able to prevent and control diseases and parasites. Become familiar with the clinical signs, causes, and treatment of parasitic infections such as lice and mange, and such diseases as cholera, erysipelas, brucellosis, leptospirosis, transmissible gastroenteritis, atrophic rhinitis, and bloody dysentery. The hogs can be housed in separate units within one large structure or in separate buildings. New or remodeled buildings should be arranged to provide appropriate environments and minimize labor needs.

If disease appears in the herd, take the following steps immediately:

1. Call a veterinarian to get an early and accurate diagnosis. State diagnostic laboratories and their services are available to producers and veterinarians.
2. Isolate all sick animals.
3. Carry out the measures recommended by the veterinarian.
4. Correct any errors in management or hygiene.
5. Destroy dead or stunted animals and clean and disinfect the premises.

Primary Specific Pathogen Free (SPF) pigs are those that have been delivered surgically from the dam two or three days prior to normal farrowing, reared in strict isolation until three or four weeks of age, and then placed in clean, conventional production units away from non-SPF stock for growth and reproduction. Secondary SPF stock is stock that has been normally farrowed by primary stock or succeeding generations.

The SPF program is designed to break the chain of disease transmission from the dam to her offspring, particularly the virus-caused diseases — mycoplasma pneumonia (formerly referred to as virus pig pneumonia, VPP) and atrophic rhinitis (AR). The program can also eliminate swine dysentery, transmissible gastroenteritis (TGE), and internal and external parasites. SPF pigs are susceptible, however, if exposed to these diseases and parasites.

Primary pigs are extremely susceptible to infections because they have not nursed the dam, and thus have been deprived of the antibody protection that is associated with the sow's colostrum. Isolate the pigs for the first six weeks to allow them time to develop their own disease-combating mechanisms. Secondary pigs, however, have the benefits of normal birth and nursing. Any animals introduced into an SPF herd should come from an SPF laboratory or an accredited SPF herd.

Under practical conditions, nutritional requirements of growing-finishing SPF swine are not significantly different from those of non-SPF swine.

Business Management

Modern confinement facilities and equipment require a large capital investment. Since these facilities have a limited use for any purpose other than pork production, the decision to invest in them indicates that the producer is planning to engage in pork production for an extended period of time.

Investment

Studies at Midwestern agricultural experiment stations have shown that when all costs are considered, the total cost of production may not be much different in a confinement system from the cost in a pasture system or a system using portable equipment.

A Purdue study compared the total cost of production from farrowing to weaning in several different kinds of farrowing units. The investment per sow and litter was least in the individual portable house system. In another Purdue study, the total cost of producing 100 pounds of pork was $17.56 in a slotted, completely enclosed finishing building, and $17.17 with a pasture system using portable buildings.

An Illinois study compared three different building systems. System A included a farrowing house and remodeled existing buildings (frequently an old barn with one side open) for use as solid-floor nursery and finishing units. A concrete floor was poured inside the building for use with an outside feeding floor. The sow herd was housed in field shelters, with water piped into the sow lots. The direct labor input for System A was estimated at 16 hours per litter. The capital investment for buildings, equipment, feed processing, and manure handling was $175 per litter.

System B consisted of a slotted-floor farrowing unit, a slotted-floor nursery unit, and an open-front, partially slotted-floor finishing unit. The direct labor input was estimated at 13 hours per litter. Capital investment for buildings, equipment, feed processing, and manure handling totaled $281 per litter.

System C included the slotted-floor farrowing house and an enclosed, slotted-floor nursery similar to that for System B, an enclosed slotted-floor finishing building, and an enclosed, slotted-floor sow-confinement building. The direct labor input for System C was estimated at 10 hours per litter.

Capital investment for buildings, equipment, feed processing, and manure handling totaled $409 per litter.

The costs of producing 100 pounds of pork in the three systems are shown below.

	System A	System B	System C
Feed	$11.50	$11.50	$11.50
Labor @ $3 per hour	2.82	2.28	1.80
Buildings and equipment	1.85	2.98	4.33
Cash expense	1.10	1.10	1.10
Interest on feed and livestock	.50	.50	.50
Overhead	.80	.80	.80
Total	$18.57	$19.16	$20.03
Litters produced per man per year	125	154	200
Return for labor of one man			
Hogs @ $18 per 100 pounds	4,760	2,940	−760
Hogs @ $22 per 100 pounds	13,300	13,480	12,560
Hogs @ $26 per 100 pounds	21,800	24,000	25,900

The difference in the total cost of production between Systems A and B was 59 cents per hundredweight. The production cost of System C was 87 cents higher than that of System B. This difference was due primarily to the cost of the sow-confinement building. The cost of System C cannot be justified on the basis of labor saved or superior sow reproductive performance, but rather on the basis that a sow-confinement building makes day-to-day management of many groups of sows much easier.

Records

Records furnish information on such important aspects of production as the number of litters farrowed and the total number of hogs sold, the average number of pigs weaned and sold per litter, the average marketing weight and price, pounds of feed per hundredweight of pork sold, and the return per $100 worth of feed fed or the return above feed cost per litter.

The basic herd record is the litter record. The minimum information that should appear on a litter record is as follows:

Sow identification_____

Farrowing data_____

Litter ear notch_____

Number of pigs farrowed: alive_____ dead_____

Date iron treatment started_____

Date given other injections_____

Observations:_____

The following information may also appear on the litter record:

Sire of litter
Litter birth weight
Litter weaning date
Number of pigs weaned
Litter weaning weight

A sow lifetime record, although not essential, will give you valuable background data for selecting replacement stock. The information on this record should include the following:

Sow identification number or ear notch
Date farrowed
Number of pigs farrowed: alive dead
Number of pigs weaned
Carcass data on offspring
(Optional) Litter birth or weaning weight
(Optional) Sire of litter
Observations:

Accurate and complete records will reveal the strong and weak points of your production system. By studying these records carefully, you can make management decisions that will result in improved production efficiency and higher profits.

For Further Reading

The publications listed below contain detailed information on specific areas of swine production.

Aerobic Treatment of Livestock Wastes. D. D. Jones, D. L. Day, and A. C. Dale. 1970. 55 pages. Bulletin 737. University of Illinois at Urbana-Champaign College of Agriculture Agricultural Experiment Station in Cooperation with Purdue University Agricultural Experiment Station, Lafayette, Indiana.

Effect of Disease and Stress on Reproductive Efficiency in Swine. Symposium Proceedings. 1970. 128 pages. 70-0. Extension Service, College of Agriculture, University of Nebraska, Lincoln, Nebraska. ($1.00)

Effects of Environment on Pork Production. A Research Review. 1971. 94 pages. AE-1063. Cooperative Extension Service, Iowa State University of Science and Technology, Ames, Iowa. ($2.00)

Farrowing Houses for Swine. A. J. Muehling and G. R. Carlisle. 1969. 16 pages. Circular 973. Cooperative Extension Service, University of Illinois at Urbana-Champaign College of Agriculture.

Reproductive Efficiency of Swine. A Research Review. 1969. 168 pages. AS-342. Cooperative Extension Service, Iowa State University of Science and Technology, Ames, Iowa. ($1.00)

Swine Handbook: Housing and Equipment. 1972. 84 pages. MWPS-8. Midwest Plan Service Publication. (202 Agricultural Engineering Building, Urbana, Illinois 61801.) ($2.00)

Swine Health: Common Diseases Affecting Baby Pigs. A Research Review. 1970. 68 pages. College of Veterinary Medicine, University of Illinois at Urbana-Champaign. ($1.00)

Swine Health: Respiratory Diseases and Arthritis. A Research Review. 1970. 96 pages. Cooperative Extension Service, South Dakota State University, Brookings, South Dakota. ($1.00)

Swine Housing and Waste Management. A Research Review. 1969. 91 pages. AEng-873. Department of Agricultural Engineering, College of Agriculture, University of Illinois at Urbana-Champaign. ($2.00)

Swine Waste Management, A. J. Muehling. Reprint from Proceedings of National Symposium on Animal Waste Management, Council of State Governments. 1971. 9 pages. (202 Agricultural Engineering Building, Urbana, Illinois 61801.)

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