Sow Gestation Housing Options

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Introduction

The method of housing breeding and gestating sows has definitely undergone transition during the last 40 years. The major reasons for housing sows indoors in individual gestation stalls compared to housing outdoors were that: (1) a worker could more easily manage a larger number of sows when feeding, vaccinating, mating, and moving individual animals, (2) a worker could control the ambient temperature aspects needed by the sow, (3) more sows could be housed in a smaller area, (4) reproductive performance of the herd could be enhanced per sow inventoried because it was easier to hand-mate, (5) each sows was individually fed, (6) fighting during time of feeding was prevented, (7) better control of the dunging area could be accomplished, (8) individual housing prevented estrous sows and gilts from excessively riding each other, and (9) fierce fighting at the time of weaning was prevented. Although gestation stalls offer the benefits of controlled management, they are perceived by many people as causing a welfare problem for the sows and gilts. The United States pork industry has intensified their interest in the options available to house gestating sows because of: (1) the banning of gestation stalls in Florida, Arizona and Oregon, and (2) the announcement by Smithfield Foods that they are eliminating the use of gestation stalls during the next 10 years.

During the first week of October 2007, The Humane Society of the United States issued a press release stating: *Specifically, we're announcing this week the launch of a ballot initiative in California to uphold the standard that even animals reared for food should be able to turn around and extend their limbs. It's as simple as that*. Californians for Humane Farms will collect more than 650,000 signatures by the end of February 2008 to place the Prevention of Farm Animal Cruelty Act on the November 2008 general election ballot (Farm Sanctuary, 2007). The referendum would prohibit the use of standard, straight-sided individual sow gestation crates.

This paper briefly discusses the options for gestation stalls. There is no single ideal system, as location, farm system, standards of stockmanship, capital availability and personal preference will all influence the selection. Each individual case must therefore be carefully considered before making a commitment to the most appropriate long-term investment.

Health and welfare of sows in groups

Some people perceive that the housing of sows as a group is more welfare friendly. However, the housing of sows in groups can have welfare problems, such as: (1) aggression during mixing of animals, (2) aggression at time of feeding, (3) bullying by dominant animals, (4) injuries of feet, leg and back due to excessive riding of each other during times of estrus, (5) excessively high feed intake by dominant animals that results in fat sows, (6) excessively low feed intake by subordinate animals that results in thin sows, (7) vulva biting, (8) wounds and scars from fighting, and (9) farrowing problems caused by fat sows (Brouns and Edwards, 1994; Arey and Edwards, 1998; Rizvi et al., 2000). The rate of injuries (i.e., broken bones, body lesions, claw lesions, strained muscles, and body condition score) can be influenced by feeding method, parity distribution within the pen, social status within a group, floor space per animal, use of bedding, physical properties of floor (slick, wet and rough floor surface), and various management procedures.

Design options for housing sows in a group

When constructing or remodeling a gestation facility, welfare issues is just one aspect of a total decision making process that involves many other factors, such as, capital costs, anticipated performance, ease of management, and operating cost. It is important that producers realize there are many components involved with the design and management of a group housing system. Some of the factors involved with group housing are indicated in Table 1. Each group housing system has benefits and drawbacks. Therefore, producers must decide what they want to achieve and then implement the design components that will most likely reach those goals.

1. **Feeding system**. High levels of aggression have been documented during feeding time in group-housed sows (Jansen et al., 2007; Sequin et al., 2006). Feed intake during gestation is restricted to prevent excessive body weight gain and fat deposition. It is known that excessive feed intake during early gestation increases embryonic death in gilts but not in multiparous sows. Excessive feed intake during gestation decease feed intake during lactation (Dourmad, 1991; Weldon et al., 1994). Excessive underfeeding of gestating sows can reduce piglet birth weight, piglet viability, and lower body fat reserves at farrowing and weaning. Research has indicated that food deprivation for 48 hours after ovulation is associated with changes in reproductive hormones, changes in metabolic hormones, a decrease in number of sperm cells transported to the sperm reservoir of the oviduct, a lower cleavage rate of embryos, and a delayed transport of ova (Mburu et al., 1998). Fasting of sows on days 10 and 11 of gestation can have detrimental effects on reproduction (Tsuma et al., 1996a,b). Thus, the control of feed is a major consideration when designing and managing a gestation facility.

a. *Electronic sow feeding (ESF) system*. The computerized feeding system allows sows to be loosely housed and fed individually (Figure 1). The suggested number of animals per electronic feeder is 40 to 65 sows (Thibault, 2004; Pig Welfare Advisory Group, 1997). The computer can be used to change the total volume of feed for each individual sow and adjusted to give each sow her entire meal in one single visit or several smaller meals throughout the day (Eddison and Roberts, 1995). Aggressive physical acts do occur while sows are waiting for their turn to enter the feeder (Jensen et al., 2000; Anil et al., 2006). One concern when using ESF has been vulva biting. With proper design of the feeder and proper placement of the feeder in the gestation pen, vulva biting has been minimized. The minimum space per sow has ranged from 18 to 32 sq ft. In general, bedding is not used with an electronic sow feeding system in the United States. There are essentially two management schemes. Option 1 uses a static group of 40 to 65 sows per pen with only one electronic feeding station. All the animals are only mixed once at the time of forming the group; thus, the group is in the same reproductive phase. Option 2 uses a dynamic group of about 80 to 200 sows with two to five electronic feeding stations. Sows are added or removed from the pen at various intervals during gestation; thus, the animals are in different reproductive phases. Addition of sows results in aggression. Although the use of an ESF system helps ensure that sows receive the correct allowance of feed, sows with low social rank have lower bodyweights, higher injury levels, lower position in the feeding order, and displaced more often from the drinkers than high-ranking sows.

b. *Feeding-resting stalls*. The use of a feeding-resting stall system allows the sows to freely roam in a large pen with other sows except when they are fed or resting (Figure 2). Although the purpose of this system is to reduce aggression during feeding, some aggression still occurs. The surface of the lying area has been total slats, partial slats, solid concrete with bedding, or solid concrete without bedding. The sows enter body length individual feeding stations (one feeding stall per sow), where they are fed on the floor or in a trough that continues in front of all the stalls. Body length stall are used to improve the welfare of the sows. The body length feeding stalls are also used as a resting area. When bedding is used, the feeding stalls are placed on an 8 in. to 16 in. high platform, depending on depth of bedding. The minimum amount of space provided per sow is 14.8 ft^2. Because each sow can randomly enter any feeding stall, individualized rationing of feed is not possible.

i. *Self-locking or manual locking individual feeding stall*. Self-locking feeding stalls are designed in a manner whereby when a sow enters the stall the rear opening is closed (Figure 3). When stalls are manually lockable, these stalls can be used for such activities as vaccination, estrous detection, and artificial insemination. Because each sow can randomly enter any of the feeding stalls, individualized rationing of feed is not possible with this feeding system unless each sow is fed by hand.

ii. *Non-locking individual feeding stall*. Researchers have investigated the influence of the length of feeding stall partition (19.5 in. wide x 6.5 ft. long body length stall, 19.5 in. wide x 15.6 in. long shoulder length stall, or no partition) and type of food (wet or dry) on the amount of aggression, frequency of changing position at the trough, and duration of time at feeding trough in groups of pregnant sows (Andersen et al., 1999). When sows were provided dry feed, it was reported that increasing the length of partitions resulted in a significant reduction in the number of bites, total aggressive behaviors and displacement at the trough; plus, the duration of time at the trough increased. When sows were provided wet feed, the number of bites or duration of time feeding at the trough was not different between body and shoulder partition feeding method. Top ranked sows received less bites toward their head, shoulder and body and were less frequently displaced at the trough than sows with a lower rank when eating from a trough with no partition or shoulder partition. Vulva bites were greater when sows consumed either wet or dry feed from a feeding stall with a body partition compared to a shoulder feeding stall or a stall with no partitions. Individualized rationing of feed is not possible with this feeding system.

c. *Stalls used for feeding only*. In an effort to conserve building space and cost for feeding stalls, a specific area is designed whereby the same feeding stalls are utilized to feed several groups of sows. This system requires labor to move the sows to and from the feeding area. In addition, each sow needs to have a feeding stall. Because each sow can randomly enter any feeding stall, individualized rationing of feed is not possible.

d. *Trickle feeding system.* Another method to possibly limit aggression and feed intake by dominant sows is the trickle feeding system (Figure 4). Sows are usually kept in stable groups (4 to 60 sows). Shoulder length barriers (18" to 35" long x 18" wide) separate the feeding trough (Rural Northern Ireland Livestock, 2007; Svendsen and Bengtsson, 1983). An auger apparatus slowly delivers .2 to .4 lbs of food per minute over a period of 15 to 30 minutes. In the ideal system, there is no incentive for sows to move away from the feeder to bully other sows. The slow rhythm of feed distribution encourages the sows to remain at the feed space for the duration of the feeding period. Because each sow can randomly enter any feeding space, individualized rationing is not possible with the trickle feeding system. The minimum lying area per sow is 15 square feet.

e. *Floor feeding.* When feeding on the floor (Figure 5), the highest incidence of aggression occurs during the first 30 minutes after delivery of the feed (Csermely and Wood-Gush, 1986). As expected, dominant sows defend the center of the pile of feed. Subordinate sows take the strategy of quickly grabbing food at the edges and moving only when forced to do so. Unequal feed intake between sows within the group has detrimental effects on body reserves, especially for the low-ranking sows. Body weight gain has been reported to be 40 to 50 lbs lower for low ranking sows when floor fed compared to high ranking sows (Brouns and Edwards, 1994). Aggression over food during a single feeding is not totally eliminated by providing piles of feed at several locations within the feeding area.

f. *Trough feeding.* The use of several feed drops per pen does not eliminate aggression during feeding when feeding space is limited per sow. Attacks and fights were very evident in an experiment that used 32 drop-feeders to drop feed into three feed trough across the width of the pen for 50 sows (Jansen et al., 2007). The size of the pen was 25.6' x 44.9'; thus, the amount of feeding space per sow was very limited.

2. **Floor surface.** Gestation sows have been kept on total slatted, partial slatted and solid concrete floors. Total slatted floors have been used primarily to enhance cleanliness of the pen. Given the option when the ambient temperature ranges from 64 F to 73 F,

sows will spend 80% to 90% of their time on a dry floor compared with a wet floor (Hutson et al., 1993).

3. **Space requirement**. Although the amount of space needed per sow or gilt is a critical factor, the optimal amount of space needed per sow or gilt when group-housed during gestation has not been adequately investigated. The suggested space requirement when sows or gilts are housed in groups in the United States is indicated in Table 2 (Harmon et al., 2001). The floor space is dependent on type of floor surface and size of animals. What trait or traits should be used to determine the amount of space per gestating sow? The primary objective of a study at the University of Illinois was to determine the impacts of floor-space allowance (14.8 ft^2, 24.3 ft^2, or 34.8 ft^2 per sow) for gestating sows in pens (5 sows per pen) on skin lesions, body weight, body weight changes, backfat, total number of piglets born per litter, number of piglets born alive per litter, number of piglets weaned per litter, litter birth weight, litter weaning weight and piglet body weight gain from birth to weaning (Salak-Johnson et al., 2007). Sows in pens at 14.8 ft^2 floor space generally had a lower body condition score, body weight, and backfat than did those sows kept in pens at 24.3 ft^2, or 34.8 ft^2 per sow. Sows kept in pens at 34.8 ft^2 floor space did farrow larger litters, however, the number of pigs weaned was similar across treatments. Sows kept in pens at 24.3 ft^2 floor space had lesser lesion scores than did sows kept at either 14.8 ft^2 or 34.8 ft^2 floor space.

4. **Animals per pen**. The optimal number of sows per pen and management procedures has not been adequately investigated in a scientific manner. A wide range in number of sows per pen and management procedures is utilized. In reality, group size is often confounded with group stability because larger groups can usually only be operated on a dynamic basis. Because the number of pens and size of pens cannot be easily changed on a farm, pork producers quite frequently add recently bred sows to a pen during the breeding phase and during the first 30 days of gestation. The variation in number of sows bred per week or group is a contributing factor to this problem. With respect to reproductive performance in two research projects, farrowing rate and litter size was not difference over the range of 5 to 40 sows or 12 to 28 sows per pen (Taylor et al., 1997; Moller et al., 1998).

5. **Hospital or relief pen**. When housing sows in groups, it is essential to have a sufficient number of pens for sick, injured or noncompetitive pigs. The requirements for a hospital pen in Denmark are: (a) maximum of 3 sows or gilts per pen, (b) 29.5 sq. ft. per animal, (c) no drafts, (d) ambient temperature must be adjustable, and (e) 66% of the total area of the pen must be soft bedding (National Committee for Pig Production, 2005).

6. **Time of mixing.** A critical question when group-housing sows and gilts is: When should the animals be grouped (mixed together)? Should the sows be mix at: (a) the time of weaning, (b) after mating (day 0 to day 7), or after implantation of embryos (day 28 to day 35)? Fighting usually lasts for 2 or 3 days after mixing (Dolf, 1986). Simulating stress (by injecting a hormone, ACTH, found during a stress reaction) at the time of estrus caused a significant loss of oocytes/embryos and a faster transport of oocytes/embryos through the oviduct (Brandt et al., 2007). Injection of ACTH during

pro-estrus caused a prolongation of the estrus cycle and disturbed follicular development (Einarsson et al., 2007).

The introduction of bred sows to an existing group of sows at one to eight days after mating has increased the incidence of bred sows returning to estrus by10 percentage points and reduced litter size by .2 piglet compared with introducing bred sows at 22 to 29 days after mating (Bokma, 1990). Research in Canada (Gonyou, 2004) found a higher number of piglets born per 100 sows bred when sows were mixed greater than 35 days after breeding compared with mixing less than 7 days after breeding (Table 3). Although the data in a Swedish study (Nielsen, 2003) is confounded between type of group (dynamic or static) and feeding method (ESF or floor fed), farrowing rate and litter size born alive was not different when sows were grouped four weeks after mating (Table 4, Herd 3). However, the percentage of sows removed from the group was two times greater in the dynamic housing method. Barbari (2000) found that grouping sows at 28 to 50 days after insemination produced more weaned pigs per sow per year compared to grouping sows at 14 to 28 days after insemination (Table 5).

Does the physical presence of a boar at the time of mixing sows reduce aggression? A study in Canada placed a mature boar in a pen containing 15 sows (24.3 ft^2 per sow) at the time of mixing (Sequin et al., 2006). Five groups of 15 sows housed with mature boars (~2 years of age) were evaluated and compared to five groups of 15 sows not housed with a mature boar. The presence of a boar did not affect the frequency of threats during either the feeding or nonfeeding periods. Total duration of fighting and average fighting bout duration were unaffected by treatment. Sows housed with a boar did receive fewer shoulder scratches postmixing than did control sows.

Reproductive performance

The method of housing sows plays an important but not exclusive part on reproductive performance of sows. Many factors influence reproductive performance, such as genetics, health, environment, geographic location, worker skill, and management procedures. Although a large number of studies have been published comparing sow performance in different housing systems, care must be taken when interpreting data generated from records gathered from several different farms. It is difficult to make absolute conclusions that one type of housing method is better than another housing system because most farms have only one system for housing sows. Table 6 indicates the influence of type of gestation housing on number of piglets born alive per litter for 19 sets of data. There is not a clear and consistent pattern of which housing system is the best. For studies comparing stalls versus group housing, the percentage of studies indicating a numeric increase in number of piglets born alive per litter was evenly split between sows housed in stalls or group pens. An analysis of records from 71 pig farms in Northern Italy (Barbari, 2000) found that housing of sows in individual stalls during the entire reproductive cycle (mating and gestation) compared to other housing systems gave better performance in number of piglets born per litter, farrowing rate, and number of piglets weaned per sow per year (Table 5). A study in Sweden (Nielsen, 2003) found the number of piglets born alive was greater when sows were housed in stalls compared with sows housed in a group immediately after service and fed with an electronic sow feeder (Table 4). However, Herd 2 in the same study found a numeric increase of .2 in live born piglets for sows housed in groups compared with sows housed in stalls.

Hoop structures

In the United States hoop structures have been successfully used to house gestating sows. Some of the factors involved with the design and management of hoop structures are briefly presented below.

Space requirements per animal. The minimum amount of bedded area per sow in a hoop structure is 24 ft^2. The amount of additional space in the hoop will depend on the type of feeding system and other management procedures, e.g. space for heat-check boars.

Animals per pen - Although the number of sows housed per hoop varies according to size of structure, method of feeding and other management procedures, the number of sows housed in hoop structures in the United States ranges from 40 to 100 head (Brumm et al., 1999).

Feeding system – Sows housed in hoops have been fed by the following methods: (1) Individual feeding stalls (lockable and unlockable rear gate), (2) floor fed, and (3) interval feeding with a self-feeder. A “centralized” feeding area has been used to feed sows; thus, the number of sows housed in a hoop is increased. The use of a centralized feeding system does require more time spent feeding sows.

Ventilation – Hoop structures are naturally ventilated and take advantage of prevailing winds. Therefore, the longitudinal aspect of the structure is in the direction whereby air moves longitudinally through the facility. In the Midwest most of the structures are oriented in a north-south direction. In general, the hoop structure has a minimal volume of air entering from the sides.

Heating and cooling systems – A heating system is not used in a hoop structure because the deep-bedded material generates heat while decomposing (Lay et al., 2000). During high ambient temperature, the sows are generally cooled with a water sprinkling system.

Floor design. Brumm et al. (1999) provided line drawings of floor plans and (or) design information for hoop structures with different feeding systems. A hoop structure is a "half-cylinder" shaped building with sidewalls 4 to 6 feet high made of treated wood posts and wood sides. In the United States, the typical outside dimensions of a hoop are 30 to 40 ft wide and 60 to 100 ft long (Brumm et al., 1999). Pens should be at least 15 ft or 16 ft wide to reduce aggression (Honeyman et al., 1997). Tubular steel arches fastened to the tops or sides of the posts form a half-circle roof, which is covered with an opaque, UV resistant, polyvinyl trap. Most swine hoop houses have a dirt floor except for a concrete feeding floor and watering pad.

Manure management. Most of the floors in hoop buildings are covered (14 to 18 in. deep) with deep-bedded oat/wheat straw or cornstalks (about 1,000 lbs per sow per gestation); however, other types of bedding material have been used (prairie hay, corn cobs, barley straw). The influence of quality of bedding on welfare, health and performance of the animals has not been extensively studied. All bedding materials should be free of molds to prevent reproductive problems during gestation. A skid-loader or a tractor loader equipped with a grappling fork is used to clean out the shelter. The quality of the solid manure for application on the land will vary greatly between the material removed from the sleeping area and the dunging area. The solid manure can either be hauled to the field directly or composed.

Labor requirements. The total amount of labor needed to operate a deep-bedded hoop gestation facility could not be located. It has been estimated that 7 to 9 hours of total labor is needed to clean the hoop structure and spread the material on nearby cropland (Brumm, et al., 1999).

Reproductive Performance. Connor (1998) compared the reproductive performance between sows housed in a hoop structure and sows housed as a group in a conventional barn system in Canada. Sows gestating in a hoop structure (731 ft^2) were housed as a single group of 24 to 30 head and fed once daily in individual feeding stalls. Sows gestating in a conventional barn were assigned to groups of four per pen (6 x 14 ft) on partially slatted concrete floors and drop-fed twice per day on the floor. There was no difference in housing method on number of pigs born alive per litter, birth weight, or average number of pigs weaned per litter (Table 7). The weaning-to-estrus interval was not different for sows housed in a hoop structure (HS) or conventional barn (CB) at parity 1 (HS, 9.0, CB, 8.5), parity 2 (HS, 6.4, CB, 5.8), or parity 3 (HS, 5.0, CB, 5.5).

Iowa State University evaluated the effect of gestating sows in either a hoop structure or individual gestation stall facility on reproductive performance for 2.5 years (Lammers et al., 2007). Sows kept in the hoop structure were: (1) housed in groups of 32, (2) individually fed in stalls within the each pen, and (3) moved into the group environment by 9 days after weaning. The reproductive performance data for 957 litters (353 sows) is indicated in Table 8. Farrowing rate data were not reported. Sows that were gestated in hoop barns gave birth to more total (11.7) and live (10.0) pigs per litter than sows gestated in stalls (11.3 total pigs and 9.3 live pigs). Sows gestated in stalls started cycling sooner than sows gestated in hoop structures (4.3 vs 6.0 days). Their overall conclusion is that sows housed as groups in deep-bedded hoop structures equipped with individual feeding stalls will perform comparably to sows gestated in confinement systems with individual stalls.

Research conducted in Australia compared the welfare and reproductive performance of gestating sows when housed in conventional stalls with that of gestating sows housed in large groups on deep litter (Karlen et al., 2007). Once a week over 8 weeks, two groups of 40 crossbred sows (Landrace x Large White) were randomly selected at weaning and housed in individual stalls to be artificially inseminated. After each sow received two artificial inseminations, they were moved to their assigned housing for gestation. Approximately 45 non-experimental recently inseminated sows were added to the pen; thus, they were 85 sows per pen. Each pen was 29.5' wide x 73.8' long. The deep bedding consisted of 12 inches of rice hulls. Each sow was provided 24.3 square feet. The hoop-housed sows were daily released from their pen to be fed in a cental feeding station located 131 to 197 feet away from their accommodation pen. Forty-five non-experimental sows were also added to the stall-housed sows. The results of the study are indicated in Table 9. There was a trend for the percentage of sows returning to estrus after mating to be greater for hoop-housed sows compared to stall-housed sows (27.3% vs 14.5%). Farrowing rate was greater for stall-housed sows compared to hoop-housed sows (76.9% vs 66.0%). Although the stall-housed sows weaned less piglets per litter (8.3 vs 9.0), the number of piglets weaned per 100 sows mated was more for the stall-housed sows compared with the hoop-housed sows (638 vs 594).

Health and welfare – Karlen et al. (2007) suggested that sows in large groups on deep litter faced greater welfare challenges in the early stages of gestation based on the findings of increased scratches, a higher rate of return to estrus after mating and a trend for higher cortisol concentrations in saliva. In contrast sows in stalls faced greater welfare challenges later in gestation based on higher incidence of lameness and an increased neutrophil:lymphocyte ratio. Holmgren and Nilsson (2000) found that the use of straw bedding increased the risk of sows becoming infected with internal parasites, e.g., *Oesophagostomum* spp. (strongyloid nematodes). Publications comparing health and welfare aspects between various types of hoop structure systems were not located.

Ease of management

An important consideration when designing a breeding-gestation facility is the ease in performing estrous detection, artificial insemination, pregnancy detection, health procedures, moving of animals (width of alley, open gates cutting off alley, ease of working gate latch), feeding and watering. Each type of breeding-gestation facility design has advantages and disadvantages with respect to the previously mentioned aspects. An important consideration is the ease to successfully artificially inseminate estrous females. If weaned sows are housed in groups, a procedure needs to be implemented whereby estrous sows can be inseminated without being ridden by other sows during the insemination process.

Fixed and variable cost

The National Pork Board recently released a CD, (*Sow Housing Alternatives Calculator*) that contain spreadsheets to estimate the cost of building or remodeling a gestation facility. The spreadsheets will evaluate the production and financial implications for remodeling an existing individual stalls gestation facility to house sows in groups, for building a new gestation facility to house sows as groups, and constructing a new hoop structure that house sows and feeds the sows either indoors or outdoors. The main input categories of the model include cost of building structure, cost of equipment, annual ownership cost, and annual variable cost of gestation facility. The following annual ownership cost can be easily changed: labor, feed, utilities, veterinary & health supplies, semen cost, loan payment, and depreciation on breeding stock. The user can enter known values or have the computer calculate values. After the total annual ownership and variable costs are calculated, the user can change the reproductive performance values (farrowing rate, litter size, and litter per sow per year) to estimate their effect on cost of the gestation phase per pig weaned.

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Pictures in this publication are used as examples only to depict a housing or feeding method. There is no intention to exclude other housing and feeding methods.

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Table 1. Factors involved with design and management of housing sows and gilts in groups

• Number of animals per pen	• Geographic location
• Size of animals per pen	• Genetic composition of sows
• Floor space per animal	• Temperament of sows
• Type of flooring Total slats Partial slats Solid concrete	• Establishing of "hospital" area Lame and injured sows Sick sows Noncompetitive sows
• Method of feeding Mechanical Non-mechanical Floor feeding Dump feed in a pile Dump with spinner to spread feed Individual feed drops Interval feeding Trickle (Biofix) feeding Locked feeding stall Unlocked feeding stall Self-locking feeding stall Electronic sow feeder	• Complexity of accomplishing work tasks Estrous detection Artificial insemination of sows & gilts Natural mating of animals Moving animals Feeding animals Treating sick animals Use of pregnancy detection device Daily observation of animals Locating a specific animal
• Thermal comfort Heating system Cooling system Use of mold-free bedding	• Aggression Time and method of mixing Time and method of feeding During daily activity of animal
• Height of pen partitions Vertical bars Horizontal bars	• Method of watering animals Animals per waterer Type of waterer
• Urination & defecation area	• Safety aspects for workers
• Eating area	• Sleeping and resting area
• Boar housing area	• Management of replacement gilts
• Composition of group Stable Dynamic (frequently changing)	• Time when to mix animals At weaning Immediately after breeding At 35 to 42 days of gestation
• Reproductive performance	• Rate of morbidity & mortality
• Capital and operating cost	• Ease of overall management
• Skill and attitude of workers	

Table 2. Recommended space requirements for sows and gilts housed in groups.

Animal	Body weight, lbs	Solid floor (sq ft/head)	Fully and partially slotted (sq ft/head)
Breeding gilt	250 to 300	40	24
Breeding sow	300 to 500	48	30
Gestating gilt	250 to 300	20	14
Gestating sow	300 to 500	24	16

Table 3. Influence of gestation system on live piglets per 100 sows bred

		Mixed pre-implantation (< 7 days after mating)		Mixed pre-implantation (> 35 days after mating)	
Item	Stalls	Static	Dynamic	Static	Dynamic
Gilts	763	666	678	734	763
1st parity	894	891	855	965	914
2nd parity	973	906	958	929	1020
Mature sows	951	910	884	995	995

Table 4. Influence of gestation housing system on sow performance

Item	**Herd 1**			**Herd 2**		**Herd 3**	
Type of housing:	Dynamic group	Dynamic group	Stall	Dynamic group	Stall	Dynamic group	Static group
Feeding:	ESF[1]	ESF	Individual	ESF	Individual	ESF	Floor
Type of Flooring:	Partly slotted	Deep litter	Partly slotted	Partly slotted	Partly slotted	Partly slotted	Partly slotted
Time of mixing:	After service	After service	-	After service	-	4 wk after service	4 wk after service
No. litters	313	348	354	455	265	364	365
Sows removed	17 %	13 %	-	29 %	-	24 %	12 %
Farrowing rate, %	83	84	87	86	94	94	95
Live born per litter	10.7[a]	10.7[a]	11.3[b]	11.9	11.7	11.8	12.0

[1] ESF = electronic sow feeder; [a,b] Means differ ($p < .05$)

Table 5. Influence of housing method on reproductive performance (71 farms in Northern Italy)

	Method housed[a]				
Item	G	S	SG1	SG2	GS
Weaning to mating	Group	Stall	Stall	Stall	Group
Stage of gestation					
0 to 14 days	Group	Stall	Stall	Stall	Group
14 to 28 days	Group	Stall	Group	Stall	Stall
28 to 50 days	Group	Stall	Group	Group	Stall
50 to 110 days	Group	Stall	Group	Group	Stall
Farrowing rate, %					
1997	76.28	77.71	69.60	72.68	70.03
1998	75.85	76.61	70.56	70.59	69.77
Average number piglets born live per litter					
1997	9.89	10.24	9.49	9.78	10.14
1998	9.87	10.18	9.50	9.63	10.24
Number of piglets weaned Per sow per year					
1997	19.78	20.82	18.61	19.27	19.28
1998	19.47	20.66	18.06	18.38	18.92

[a] G is group housing for the entire time of mating and gestation.
S is stall housing for the entire time of mating and gestation.
SG1 is stall housing during mating and grouping during 14 to 28 days of gestation; group housing remaining period of gestation.
SG2 is stall housing during mating and grouping during 28 to 50 days of gestation; group housing remaining period of gestation.
GS is group housing during mating and housing in stalls 14 to 28 days of gestation; stall housing remaining period of gestation.

Table 6. Influence of gestation housing system on number of piglets born alive per litter

		Group-housed indoors				
	Stalls	Floor	Feeding stall		Electronic	Trickle
Location of study	indoors	Fed	Locked	Open	feeder	feeder
Nebraska	9.80	9.60				
Netherlands	10.31				10.11	
Sweden	11.03	10.88	11.13			
Sweden	11.80	11.50				
United Kingdom	10.77	10.70				
Netherlands	10.70			10.90	11.00	10.70
Sweden	10.20			10.10		11.30
Sweden	10.40			10.20		
Sweden	11.42	11.21	11.34			
Texas	8.90	9.90				
United Kingdom				10.20	10.50	
Sweden					10.02	10.32
Minnesota (Parity 1)	9.80				10.50	
Minnesota (Parity 2)	10.11				10.12	
Denmark (Herd 1)	11.2	10.7				
Denmark (Herd 2)	11.4	11.6				
Denmark (Herd 3)	11.9	11.4				
Kansas	9.77				9.77	
Sweden						
(gilts)			9.1		9.7	
(sows)			11.8		10.8	

Table 7. Effect of gestation housing type on average number of pigs born alive per litter, average birth weight, or average number of pigs weaned per litter (mean ±SD).

Housing method	Parity	Number of litters	Number born alive per litter	Birth weight, lbs	Number pigs weaned per litter
Hoop	1	87	9.9 ± 2.8	3.02 ± .47	8.8 ± 2.6
Barn	1	73	9.3 ± 2.8	3.24 ± .56	8.6 ± 2.9
Hoop	2	64	11.1 ± 3.0	3.40 ± .50	9.6 ± 2.7
Barn	2	59	11.2 ± 2.6	3.33 ± .47	9.5 ± 2.1
Hoop	3	46	11.9 ± 3.2	3.42 ± .63	9.8 ± 2.9
Barn	3	58	12.1 ± 2.7	3.33 ± .47	10.1 ± 2.6
Hoop	4	29	12.3 ± 2.7	3.28 ± .47	9.5 ± 2.0
Barn	4	27	11.6 ± 3.0	3.06 ± .63	9.0 ± 3.0
Hoop	5	7	10.8 ± 3.0	3.08 ± .50	8.2 ± 3.4
Barn	5	10	11.0 ± 3.4	3.26 ± .50	8.2 ± 1.6
Combined data					
Hoop		233	11.0 ± 3.0	3.24 ± .54	9.3 ± 2.7
Barn		227	10.7 ± 3.0	3.26 ± .54	9.2 ± 2.6

Table 8. Effect of gestation housing on reproductive performance of sows

Item	Stall	Hoop	P-value
Number of litters	552	405	
Average parity	4.4	4.6	0.30
Number born alive per litter	9.3	10.0	0.002
Number of stillborn per litter	2.0	1.7	0.055
Total number born per litter	11.3	11.7	0.05
Number of mummified fetuses per litter	0.21	0.25	0.28
Litter size after cross-fostering	10.5	10.4	0.70
Lactation length, days	18.8	18.8	0.98
Litter weight at birth, lbs	35.7	35.9	0.44
Preweaning mortality, %	14.0	15.0	0.72
Number piglets weaned per litter	8.9	8.8	0.48
Litter weight at weaning, lbs	124.6	125.9	0.40
Litter weight gain, lbs	89.1	88.8	0.93
Weaning-to-breeding interval, days	4.3	6.0	0.01

Table 9. Effect of gestation housing on number of piglets and litter weights

Item	Stall	Hoop
Return to estrus after mating, %	14.5	27.3
Farrowing rate, %	76.9 [c]	66.0 [d]
Number of piglets per litter		
Total born	11.2	11.1
Born alive	10.1	10.2
Stillborn	0.7	0.6
Mummified	0.3	0.3
Weaned	8.3 [e]	9.0 [f]
Born alive per sow mated	8.3 [e]	6.4 [f]
Weaned per sow mated	6.0	5.9
Preweaning mortality, %	17.8	11.8
Litter weights, lbs		
Total litter weight at birth	35.9	35.5
Average piglet weight at birth	3.5	3.5
Total litter weight at weaning [a]	158.7	157.2
Average piglet weight at weaning [a]	19.2	17.6
Fecundity index (weaned piglets) [b]	638	594

[a] All sows were weaned on the same day; however, sows from the hoop structures farrowed on average two days later than sows gestated in stalls

[b] Fecundity index = farrowing rate x number of piglets weaned per litter

[cd] Values within row are different ($P < 0.001$)

[ef] Values within row are different ($P < 0.05$)

Figure 1. Example of an electronic sow feeder

Figure 2. Examples of a feeding and resting stall that can be locked or unlocked

Figure 3. Examples of a self-locking feeding stall

Figure 4. Examples of a trickle-feeding system (biofixation)

Figure 5. Examples of floor feeding by dropping feed in several locations within a gestation pen.