

## Animal Well-Being



# Group Housing Systems: New and Conversion Construction

The statements and opinions expressed in this article are those of the author(s).

## Objectives

- Discuss the thought process in transforming a traditional stall breeding/gestation barn to a group housing system;
- Explore the primary options and the factors that impact the selection of those options;
- Evaluate the changes in capacity associated with different options;
- Consider impacts on infrastructure such as water, ventilation, heating and cooling systems.

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## Introduction

The move from more traditional stalled breeding and gestation facilities to group housing can be challenging when it comes to remodeling current facilities or in designing new facilities to meet group-housing requirements. The ultimate goal is to provide a positive environment that promotes the welfare of sows while providing good animal flow to keep animals and people safe, the ability to properly observe animals and provide these aspects in an economical manner. There are many decisions to be made in laying out gestation facilities. Remodeling a current facility constrains those decisions. Understanding the options that exist, the constraints to making choices, and how to make efficient use of the space is the focus of this paper. Proper and thorough planning can avoid problems during construction and compromises that lead to problems in the operation of the building. It can also help to find the most economical solution that meets your needs.

## Approaching Remodeling

A new building, while perhaps a challenge to design, is always easier because it is essentially a blank slate. When remodeling a facility there are things that constrain choices and compromises that are necessary. The key is not to compromise on things that will harm the operation of the building or make working in the building a daily nuisance. It is surprising how having an alley 6 inches too narrow or low hanging pipes that force workers to duck can impact the daily tasks and perhaps cause unseen expenses (for example inefficient use of staff time, or increased staff frustration and turnover) that outweigh any original savings realized by not dealing with the problem at the start.

There are many considerations that go into remodeling a breeding and gestation facility. Many people focus on the pens and gating (such as free-access stalls, non-gated stalls, or large open pens), or they focus on the feeding system (such as the number of feed drops, trickle feeding, floor feeding, or electronic sow feeding). While both issues are very important, there are a myriad of issues which influence the choice. As with any remodeling, some things are easily changed to meet the new needs, while others are much more challenging. Every change has a cost and picking the most effective and most efficient path is important to maintain reasonable costs, but also to end with a facility that operates properly.

The two issues which limit choices most in remodeling swine facilities are the flooring system and the building width. The flooring type is important because stall systems have varying needs for slatted flooring in certain areas to prevent manure buildup causing sanitation concerns, and slippery flooring which could contribute to foot and leg problems. Sometimes large group pens need solid flooring in certain locations but this is more easily added than adding slatted areas. Typical flooring can be either fully slatted over a deep manure pit, or partially slatted over a flush gutter, scraper gutter or shallow pull plug pit. Partially slatted systems normally provide slatted flooring of 8' or 10' which serves two rows of stalls and the 2' alley behind them. Occasionally double 8' slats (total 16 ft wide) are used. Selecting a system which matches with the flooring system is essential. The building width is important because many systems are somewhat modular and require some minimum width to function properly. Modules are combined with animal movement alleys to form the unit. Wasting space with inefficient choices could be costly. Assembling the proper modules

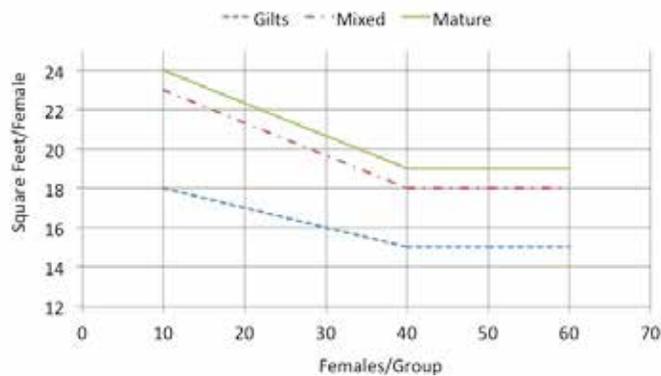
to fit the right flooring and building width somewhat resembles working a puzzle.

Before beginning to design sow group housing penning modules within the building it is important to set a goal for space. Space needs are defined by animal weight and group size. Groups of sows that are from mixed parities should be provided 18 to 23 square feet (ft<sup>2</sup>) per animal [1]. This varies by group size with a small group of 10 sows requiring 23 ft<sup>2</sup> per sow and a larger group of over 40 sows requiring 18 ft<sup>2</sup>/sow. Likewise, groups of gilts require 15 to 18 ft<sup>2</sup> and groups of mature sows 19 to 24 ft<sup>2</sup>, depending on the group size. Figure 1 can be used to see the trend in required area for various size groups [1]. Table 1 provides space requirements for planning purposes [1]. The space allocation sows have available for use will be referred to as “net square footage” (NSF) in this paper. Other factors such as dynamic or static grouping affect space requirements as well. Consideration for the future demands of voluntary welfare codes or requirements to meet supplier criteria for space in the future should be considered as this is essentially the single largest variable in allocating space to group-housed sows.

**Table 1. Space requirements (NSF) for planning purposes based on pen size and sow parity [1].**

No. of Sows/Pen	Gilts (ft <sup>2</sup> /gilt)	Mixed Parity (ft <sup>2</sup> /sow)	Mature (ft <sup>2</sup> /sow)
10	18.0	23.0	24.0
14	17.6	22.3	23.3
18	17.2	21.7	22.7
20	17.0	21.3	22.3
24	16.6	20.7	21.7
28	16.2	20.0	21.0
32	15.8	19.3	20.3
36	15.4	18.7	19.7
40 or more	15.0	18.0	19.0

**Figure 1. Space requirement per female for groups of gilts, mixed parity sows and mature sows by group size [1]. For building purposes, considered net square footage (NSF).**



One of the debated issues is the accounting of space within stalls that animals can freely enter and exit toward the overall

NSF. Normally 40 to 60% of sows will choose to lie within the stalls at any one time, depending on the comfort level of the flooring within the stall. If systems are designed with a goal of only providing the opportunity for sows to leave the stalls, then assuming that 50% of the sows are within crates at any one time is an adequate assumption when calculating space provided [2]. If a more enriched environment for sows is the goal, then assuming a higher percentage of sows would be using the open communal area at one time should be considered. This issue may become more clearly defined as further research is conducted.

## Pen Modules

The following sections are descriptions of each type of system. Specific information is given on required widths of aisles within pens, flooring considerations and alleys between pens for animal flow and movement. Example layouts are given for different size groups because the animal density changes with group size as shown in Table 1. Examples are based on “mixed” group space allocation. In order to compare systems from a whole barn space utilization standpoint a “gross square footage” (GSF) is computed. This figure incorporates animal movement alleys and space not counted in the NSF. It is the total area of a module divided by the number of sows. This will be somewhat useful in estimating building capacity changes. The main system modules to be considered in this paper include:

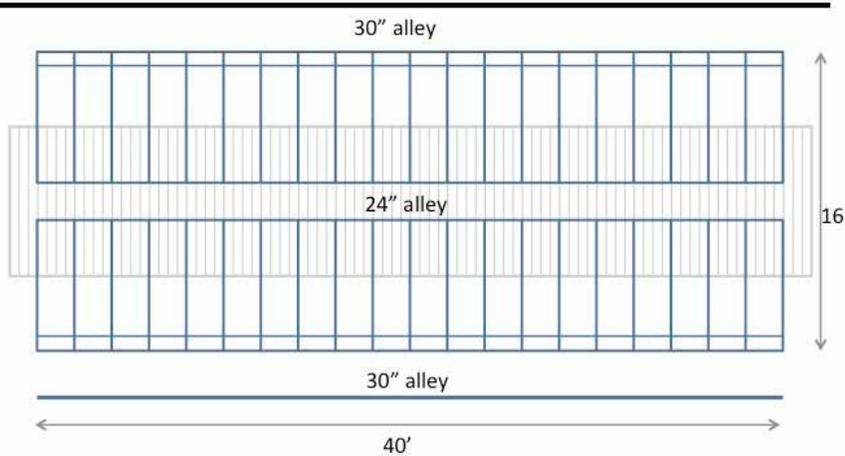
- Traditional breeding stalls used for a period post-breeding.
- Free-access or lock-in stalls
- Non-gated stalls
- Floor feeding pens
- Electronic sow feeding pens

## Traditional Breeding Stalls

There are two reasons to begin a discussion about penning modules with traditional breeding and gestation stalls. First of all, many systems continue to use traditional stalls for the period immediately post-breeding. In most systems the schedule is based on 35 to 42 days within the breeding stall. If post-breeding stalls are to be utilized, a building remodeling plan should include keeping the appropriate number of stalls. The other reason to include them in this discussion is to give a frame of reference for other changes. An example of traditional breeding stalls over a floor with 8’ slats appears in Figure 2.

Traditional breeding stalls normally are 2’ x 7’ and have slatted flooring under at least the rear 30” of each stall (no more than 54” of solid flooring) but may be placed over a fully slatted floor [3]. Troughs are included at the front of the stalls for feed and water within the stall thereby shortening the length available for laying. In most systems, animal movement alleys behind the sows are 24” and those in front are 30” or 36”. An alley is required on both ends of the stall to allow the sow to enter through the rear of the stall and exit through the front. Figure 2 shows a module of 40 sows with an 8’ slat under the rear of the stall. An 8’ slat used with a 24” alley allows 3’ of slats under the rear of the stalls. A 10’ slat would allow 4’ under the rear of the stalls.

**Figure 2. Example traditional breeding crate design layout with 40 sows in 2x7' stalls shown over an 8' partially slatted floor as an example. Sows are provided 14 ft<sup>2</sup>/sow and the GSF is computed as 18.5 ft<sup>2</sup>/sow.**



This module will be 18.5' x 40' when assuming it includes the entire alley between the rows and half of the two outer alleys. The complete module in this case requires 740 ft<sup>2</sup> for 40 sows or a GSF of 18.5 ft<sup>2</sup>/sow. This will be used as a benchmark to help evaluate the reduction in capacity which will be typical for various penning types. This is the most efficient system from a utilization of floor space standpoint.

### Free Access Stalls (FAS)

Free access stalls are a type of non-competitive feeding system in which sows have access to a pen communal area and may enter the stalls at their own choosing. Most stalls have self-locking rear gates which close and lock behind the sow after she enters the stall. The sow then triggers a latch as she backs out of the stall which unlocks the rear gate. Sows can be locked into stalls by workers when needed. These stalls are generally longer than traditional breeding and gestation stalls. Companies providing FAS equipment offer lengths that vary from 90" to 96" with typical widths generally 24.4" to 26" (center to center) with wider and longer models available. Generally, FAS stalls do not open from the front so they have the advantage of being able to be placed against a wall or head-to-head if space considerations dictate the removal of an alley. This of course complicates the ability of herdsperson from addressing hand-feeding supplementation they may wish to do to regulate body condition of individuals.

The rear aisle width between two rows of FAS should be between 7' and 10'. This is to allow sows to back out of stalls across from each other without being inhibited in their movement and possibly having an aggressive interaction with sows backing out the other side. The actual required distance is a matter of debate with some entities stating that 10' is the minimum while others feel 7' is adequate [4]. No definitive research or extensive experience answers this question fully though a 10' aisle would provide better unimpeded animal movement. This variation will allow flexibility when remodeling facilities.

In laying out pen designs it is important to provide adequate space outside of the stalls for animals. Normally 40 to 60% of the sows will lie within stalls at any one time, therefore the assumption can be made that only those sows outside of the stalls need the

full space allotment. In terms of a practical accounting of space, half of the stalls can then be counted as contributing toward the overall NSF while the other half would not be considered because they would be unused. This essentially amounts to a 50% credit which may be given for space provided within stalls toward the overall required space and would be added to the space provided in aisles and other communal areas. The remainder of the space needs to be provided in the aisle between rows and often with a communal area in one area of the pen. It is generally recommended that communal areas should be solid flooring, either concrete or mats, to provide a better level of

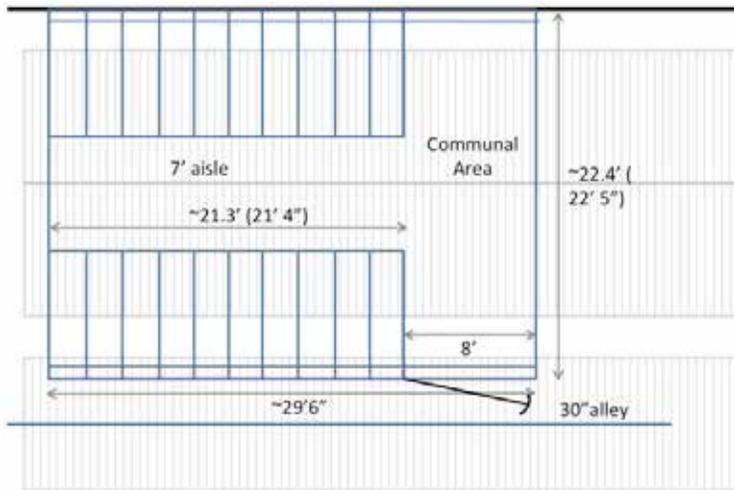
sow comfort [2]. Solid pen dividers, either concrete or solid gating, and a water source may also be added to the communal area to improve the "quality" of the space as perceived by the sow and thus encourage better use of communal area space.

There are various ways to lay out free access stalls including "T", "I" and "L" designs. Figures 3 through 6 show various layouts for different group sizes and various slatted flooring configurations. They merely serve as examples and are meant to convey the thought process of remodeling or new construction planning. For the sake of consistency, free access stalls were assumed to be 25.6" x 92.5", or 16.4 ft<sup>2</sup>. Because FAS are longer than a conventional gestation stall, care should be taken to ensure that there is no more than 54" of solid flooring within the stall, thus allowing adequate slatted flooring for manure removal. For the example FAS, the minimum slatted area should extend at least 38.5" under the rear of the stall to maintain no more than 54" of solid flooring. When designing a layout take the actual dimensions of the FAS that you select into account.

### Example "T" Design – Figure 3

The "T" design shown in Figure 3 shows 20 stalls with a communal area across one end. The aisle between the rows of stalls is shown as 7' and meant to be a minimum. A wider aisle would provide a higher quality space but 7' may be an acceptable compromise during remodeling as long as overall space requirements are met in a communal area. A minimum width in the communal area of 8' would probably be an appropriate goal to allow better sow movement. This communal area functions best if the floor is solid, either by using mats or placing concrete over the current slats. Sows prefer lying against penning that is solid and this should be considered. However, solid partitions on small pens tend to inhibit air flow and may contribute to heat stress. Water should be provided in the communal area in addition to that provided within stalls. The "T" design works well for moving sows in and out of the pen through a gate in the communal area to the exterior alleys.

**Figure 3. Example “T” free-access design for 20 sows shown over double 8’ slats. The NSF is 24.6 ft<sup>2</sup>/sow and the GSF is 34.9 ft<sup>2</sup>/sow.**



This example is shown with one row of stalls moved against the outer wall. This is another compromise point in that it eliminates the ability to top dress feed that is provided and makes animal observation within stalls more difficult because of the lack of an outside alley. This design would require removal of the existing feed trough and moving the feed auger line. In this example, because double 8’ slats are in place using the outer alley gains some useable space. However, if only a single 8’ slat (or 10’ slat) was provided the stalls could not be moved to the outer wall because stalls would then lack an appropriate amount of slatted flooring under the rear of the stalls.

To assess the total space provided, half of the total stall area can be credited toward the space provided. The remainder of the required space is provided through communal areas between rows of stalls and elsewhere. Using Figure 3 as an example, the NSF provided is calculated as:

$$\frac{(20 \text{ stalls} \times 16.4 \text{ ft}^2/\text{stall} \times 50\%) + (7' \text{ aisle} \times 21.3') + (8' \times 22.4')}{20 \text{ sows}} = \frac{492 \text{ ft}^2}{20 \text{ sows}} = 24.6 \text{ ft}^2/\text{sow}$$

This is considerably more than the stated goal of 21.3 ft<sup>2</sup>/sow for a 20 sow pen, which is taken from Table 1 for a group of 20 mixed parity sows. This design would also have a GSF, which includes all the pen space plus half of the alley potentially shared with other pens. From Figure 3 as an example, the GSF is calculated as:

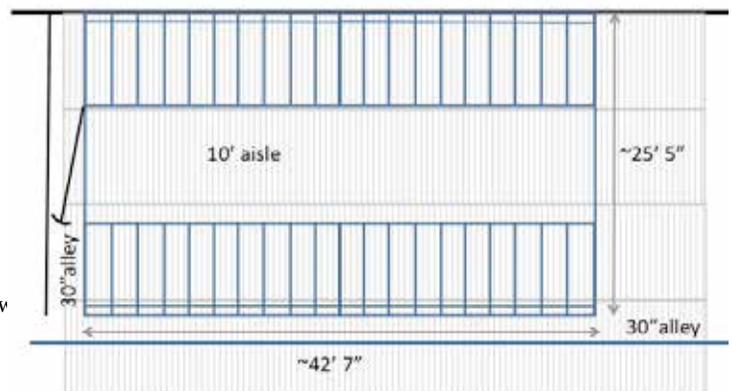
$$\frac{29.5' \times (22.4' + 2.5'/2)}{20 \text{ sows}} = \frac{698 \text{ ft}^2}{20 \text{ sows}} = 34.9 \text{ ft}^2/\text{sow}$$

## Example “I” Design – Figure 4

The “I” design shown in Figure 4 is created merely by moving the rows of stalls far enough apart to provide the necessary space only in a center aisle. This system is difficult to adopt in remodeling unless the building is fully slatted. Existing feed troughs and feed auger lines would need to be moved also. New facilities can be designed to provide slatted floors in the proper locations.

Because FAS generally do not open from the front, a means of moving sows in and out of the pen needs to be provided from the side. For this example one end of the 10’ aisle for each pen would require a gate that opens into a 30” alley at the end of every second “I” pen. This requires extra space and can create a blind alley in some instances which can be a safety concern. In this example there is no alley at the front-end of one row of stalls and it has the disadvantage of not facilitating top-dressing of feed. A pen of 40 sows should be provided with 18 ft<sup>2</sup>/sow or 720 ft<sup>2</sup> total (Table 1). In this example 50% of the stalled area provides 328 ft<sup>2</sup> (16.4 ft<sup>2</sup>/stall x 40 stalls x 50%), and therefore an additional 392 ft<sup>2</sup> is needed in the center communal aisle. The needed area divided by the pen length yields the required aisle width. Therefore, 392 ft<sup>2</sup>/42.6’ yields a needed aisle width of 9.2’ or 10’ to provide a buffer. Therefore, this design has a NSF of 18.5 sf/sow and a GSF of 29.2 ft<sup>2</sup>/sow if half of the outer alleys are counted.

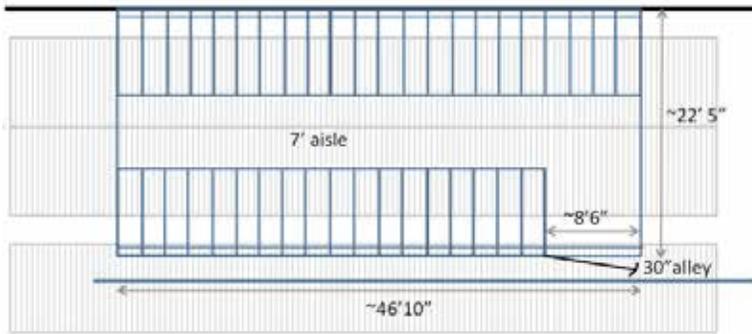
**Figure 4. Example “I” free-access design for 40 sows shown over a fully slatted floor. The NSF is 18.5 ft<sup>2</sup>/sow and the GSF is 29.2 ft<sup>2</sup>/sow.**



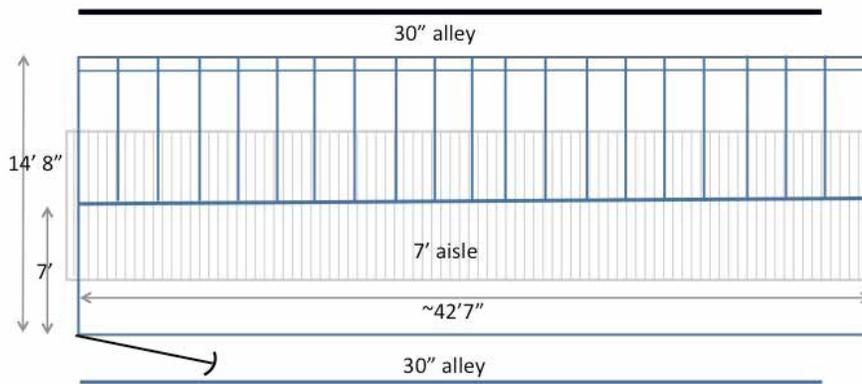
## Example “L” Design – Figure 5

The “L” example shown in Figure 5 is similar to the “T” design except the communal area is only at the end of one row of stalls. This example utilizes the space better because the group size is larger, 40 in this case, so the required space per sow is lower as opposed to the 20 sows in Figure 3. Exit from the pen is through the communal area and eliminates the need for extra cross-alleys in the building. In this case, the required space and the provided space are both 18 ft<sup>2</sup>/sow. The GSF value for this example is 27.7 ft<sup>2</sup>/sow.

**Figure 5. Example “L” free-access design for 40 sows shown over a partially slatted floor. The NSF is 18.0 ft<sup>2</sup>/sow and the GSF is 27.7 ft<sup>2</sup>/sow.**



**Figure 6. Example single row free-access design for 20 sows shown over a partially slatted floor (8' slats). The NSF is 23.1 ft<sup>2</sup>/sow and the GSF is 36.6 ft<sup>2</sup>/sow.**



### Example Single Row – Figure 6

Figure 6 shows an example of a challenging conversion which uses a single row of FAS over an 8' slat. The stalls cannot be moved to utilize the 30" alley because it would limit the slatted portion of the stalls to approximately one foot at the rear of the stalls. In this case the rear penning used to form the aisle behind the pens would be more difficult to install because the anchors will need to be installed in the concrete slab and there is a long penning length with no cross penning to add rigidity to the gating system. emphasizes how important anchorage of penning is in this situation. See the section on anchorage of posts for more discussion. Avoiding long unsupported pen lengths would be the best solution but not always practical. Anchoring posts to the slatted floor is accomplished much easier. In this case the feed trough at the rear of the pen may be left in place but the feed auger line would be unused.

For this 20 sow example 21.3 ft<sup>2</sup>/sow would be required (Table 1). The rear aisle is shown to be 7' so that the pen gating coincides with the original traditional stall layout. This provides a NSF of 23.1 ft<sup>2</sup> and a GSF of 36.6 ft<sup>2</sup>/sow.

### Non-gated Stalls

Non-gated stalls are part of a competitive feeding system. Feeding

can be accomplished with either drops or with a trickle feeding system. In either case sows receive feed in a trough that is divided by barriers. These vary from as short as 19" to as long as 6' [5].

The longer the barrier, the less competitive the feeding situation becomes [6]. With short barriers the space is considered as completely usable because sows will lie within that area without truly being "in" a stall. Longer stalls, perhaps more than 2' in length, may be less usable as communal areas and should be accounted for as 50% of the available space as was done with FAS.

Barriers can be purchased and installed. However, some producers may opt for modifying existing stalls to serve as barriers. This can be accomplished by simply removing the rear gate, in which case there is a full-length barrier (7') or stall partitions may be cut off to form shorter barriers. While cutting existing stall

partitions may seem simple and provide more efficient space utilization, it can be challenging in that most stall partitions have only two anchors that fasten to the floor. In cutting the partition one of these anchors will be eliminated so some manner of anchoring to the floor will need to be created by welding a new "end" to the gate extending to the floor. This end may be anchored to the floor at this point but may be close enough to the existing anchor as to not create an overly rigid frame. Some suggest fastening posts to the ceiling to support cut stall partitions

but care should be taken not to change the loading on trusses and harm the structural integrity of the building. Welding rod across the tops of stall partitions can help make the row more rigid. Even with this challenge, the transformation may be cost effective and worth consideration. Care should be taken to be sure any sharp edges or "pinch points" are eliminated after partitions are cut to protect animals and workers.

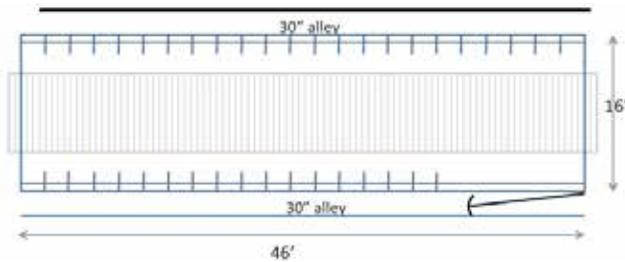
Non-gated stall layouts often are used in remodeling because the basic layout remains the same and often equipment can be modified to minimize the purchase of new equipment. It is a competitive feeding system and as such has unique challenges for achieving success. It is probably one of the most cost efficient transformations, but may be a challenge in managing sows for uniform conditioning. In buildings with partial slats, especially 8' slats, it should be considered. Examples of several different layouts follow.

### Short Dividers Examples – Figures 7 – 9

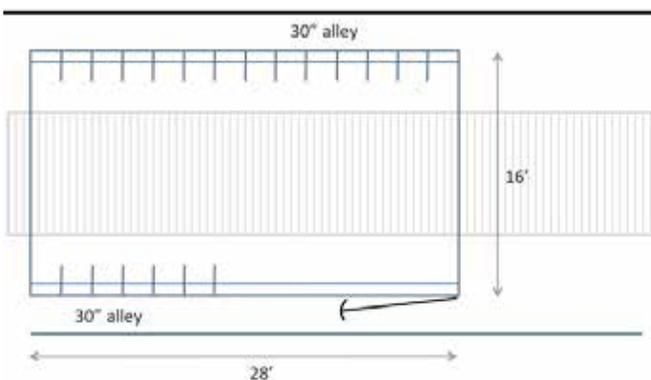
Figures 7 through 9 show one relatively simple transformation when remodeling. In these situations the outer penning would remain as it was for the traditional stall layout but partitions would be cut to 2'. A few partitions would be removed entirely to provide a communal area to meet the overall space needs for the group. This minimizes moving gating and positions stalls in the

proper location in regards to the slats. Additional welding would be required to fully support the dividers and penning. The trough and feed auger lines would remain as well; continuing through the communal area to give sows an additional area for drinking. This would also provide a way to feed an extra sow when the group is larger than the design capacity. Removal of sows from the pen would be easy as well with a gate provided in the communal area.

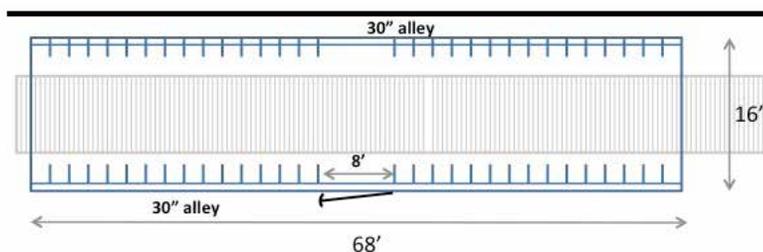
**Figure 7. Example non-gated stall design for 40 sows shown over a partially slatted floor (8' slats). This assumes stall partitions have been cut to create 2' dividers. The NSF is 18.4 ft<sup>2</sup>/sow and the GSF is 21.3 ft<sup>2</sup>/sow.**



**Figure 8. Example non-gated stall design for 20 sows shown over a partially slatted floor (8' slats). This assumes stall partitions have been cut to create 2' dividers. The NSF is 22.44 ft<sup>2</sup>/sow and the GSF is as 25.9 ft<sup>2</sup>/sow.**



**Figure 9. Example non-gated stall design for 60 sows shown over a partially slatted floor (8' slats). This assumes stall partitions have been cut to create 2' dividers. The NSF is 18.1 ft<sup>2</sup>/sow and the GSF is 21.0 ft<sup>2</sup>/sow.**



Sows will tend to lay with heads between dividers at times and so full credit is given for the entire space. Therefore, in the example in Figure 7 a space which held 46 sows in 2' x 7' gestation stalls is transformed to hold 40 sows, a reduction of only 15%. This

provides a NSF of 18.4 ft<sup>2</sup>/sow (as compared to 18 required) and a GSF of 21.3 ft<sup>2</sup>/sow when half the aisles are included.

The example in Figure 8 provides 22.4 ft<sup>2</sup>/sow (as compared to 21.3 ft<sup>2</sup>/sow required for a group of 20 sows) and a GSF of 25.9 ft<sup>2</sup>/sow. More space per sow is required because of the smaller group (Table 1). Figure 8 represents a reduction of 29%. Figure 9 shows a 60-sow pen with NSF of 18.1 ft<sup>2</sup>/sow (18 required) and a GSF of 21.0 ft<sup>2</sup>/sow. The reduction in this case is from a pen of 68 to a pen of 60, or a 13% reduction. The communal area in this case is shown in the center, which may have advantages of encouraging usage by sows, but will likely make animal removal from the pen more challenging than it would if it were on the end of the pen. It should be noted that larger pens are more efficient because the space requirement per animal is lower (see Table 1) but there may be animal management advantages to creating smaller pens.

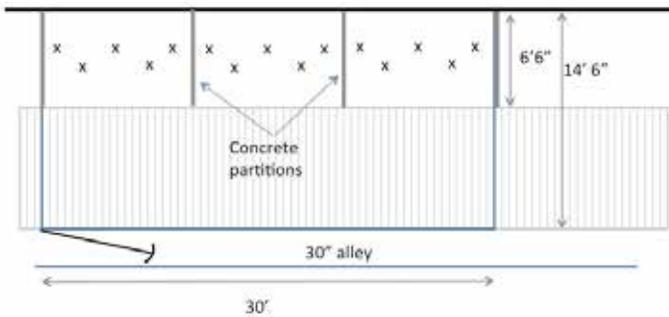
### Long Dividers Example – Figure 10

Figure 10 represents an idea that is relatively easy from a remodeling standpoint but inefficient in that a reduction of 50% would be associated with this design. In this scenario one row of stalls would be removed and the rear gates from the other row would be removed. Longer stall dividers would reduce the aggression during feeding but only half of the space should be credited toward the overall space (as was done with free access stalls). In this example a 20-sow pen is created, providing a NSF of 25 ft<sup>2</sup>/sow and a GSF of 37 ft<sup>2</sup>/sow. In this case, the rear penning remained in the same location, providing a 16' wide pen. The pen could be narrowed to better utilize the space and provide the minimum space requirement. This represents a relatively easy remodeling effort but a reduction of capacity of 50%. Dividers that are shorter than 7' and longer than 2' could be used.

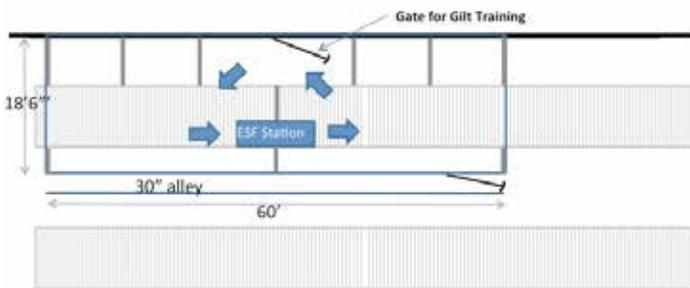
### Floor Feeding

Floor feeding can be one of the simplest systems from an equipment standpoint but yet presents many challenges from an animal feeding standpoint. Feed is simply dropped on the floor. In the simplest form, feed drops are used to drop feed in as many spots as is practical. To reduce the competitive nature of the system multiple strategies of managing floor feeding can be employed including trickle feeding, interval dropping of feed or staging feeding within different areas of the pen which are divided by extra penning [5]. Generally it is felt that some form of solid partitions within the pens reduce aggression [6]. Figure 11 shows the simplest of systems with a combination of solid flooring and slatted flooring. This system would create a relatively competitive environment and further design of penning to accommodate the feeding method would help to reduce aggression. In remodeling a building that is fully slatted, concrete can be placed in areas where feed is to be dropped. The feeding area should be sufficiently large to avoid feed going through the slats. A reasonable goal would be to drop feed at least 4' from the slats. Spacing the drops as far apart as possible helps to reduce aggression.

**Figure 10. Example non-gated stalls design for 20 sows shown over a fully slatted floor (8' slats). This assumes rear gates of stalls were removed. The NSF is 25.0 ft<sup>2</sup>/sow and the GSF is 37.0 ft<sup>2</sup>/sow.**



**Figure 11. Example flooring feeding design for 20 sows shown over a partially slatted floor (8' slats). Solid partitions are added to reduce sow aggression. The NSF is 21.8 ft<sup>2</sup>/sow and the GSF is 23.6 ft<sup>2</sup>/sow. Feed drop locations are shown with an "x".**



**Figure 12. Example ESF design for 60 sows shown over a partially slatted floor (8' slats). Solid partitions are added to reduce sow aggression and prevent aggressive sows from returning to the entrance immediately after exiting. The NSF is 18.5 ft<sup>2</sup>/sow and the GSF is 19.8 ft<sup>2</sup>/sow.**

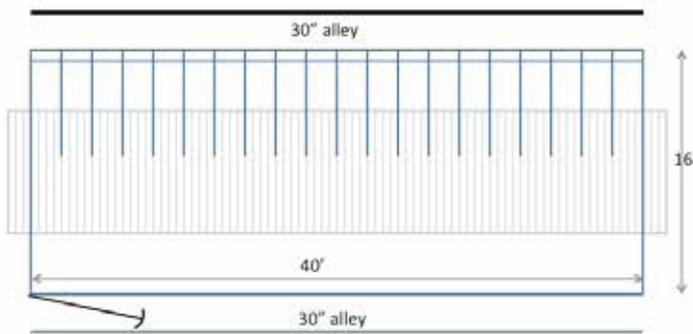


Figure 11 shows a basic layout for 20 sows. Pens have concrete dividers to provide some protection from aggressive feeding sows and will also facilitate the use of the solid concrete for laying. The minimum space required is 21.3 ft<sup>2</sup>/sow with a NSF of 21.8 ft<sup>2</sup>/sow provided. The pen only requires an aisle on one side and so the GSF for this particular design is 23.6 ft<sup>2</sup>/sow. A drop is shown for each sow, which would likely cause the least aggression, but may not be practical in some cases. A larger version of this pen to hold 40 sows would look much the same but would only need to be 50' long due to the space requirement for a sow in a larger group only being 18 ft<sup>2</sup>/sow. This would have a NSF of 18.1 ft<sup>2</sup>/sow and a GSF of 19.7 ft<sup>2</sup>/sow.

## Electronic Sow Feeding (ESF)

Electronic sow feeders are normally used for either a single static group of up to 60 sows per electronic sow feeder (ESF) or a dynamic group with sows at various stages of gestation. Dynamic groupings normally have some type of sorting system in order to separate out groups approaching their farrowing date. ESF systems should also incorporate a gilt training area to familiarize gilts with the system prior to service. This has been found to positively influence reproduction and sow conditioning. [7]

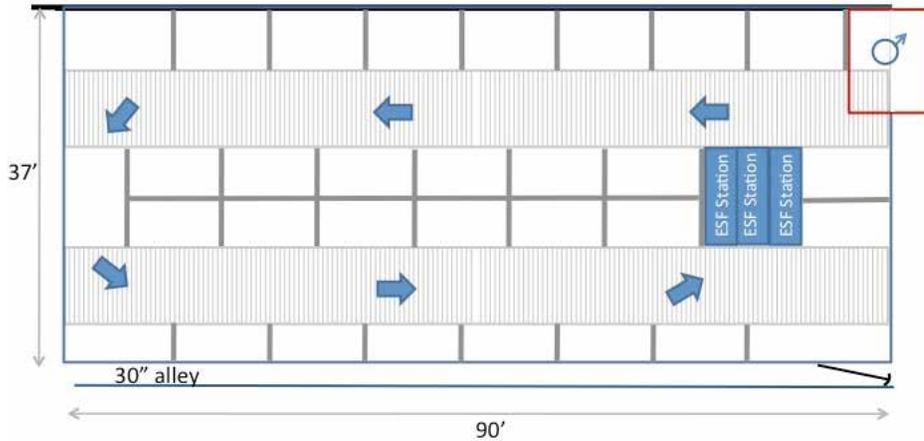
The basic layout for ESF penning systems provide three zones, [8] the pre-feeding area, post-feeding area, and a communal area. The pre-feeding area is where sows essentially form a line to enter the feeding station. This area, as well as the area where animals exit the feeding station, should be slatted. The communal area provides areas out of the flow of animal movement to allow for resting. One important aspect of the entire configuration is animal flow to and from the feeding station. Animals that finish eating should not be allowed to return immediately to the entry of the feeding station. This is accomplished by lengthening the pathway from exit to entrance. This keeps sows from dominating the station and reduces skin lesions.[7,9] Most companies selling ESF systems have example layouts that may be helpful.

Figure 12 shows an example of an ESF system designed for 60 sows. This is shown on a partially slatted floor since this system is most restrictive in the configuration. The feeding station is located near the center of the pen on the slats. Solid partitions are used to create distinct lying areas on the solid concrete. In a pen this small it is difficult to prevent animals from returning quickly to the entrance of the station after exiting but partial walls were added on either side of the station to make return more difficult. A gate is shown which could be used in training gilts. Gilts would be positioned on the entrance side of the station and the gate closed. Animals would then file through the feeding station but would be unable to return. The lack of competition as more animals go through the station would allow more timid animals the chance to enter and learn the procedure. Due to the size of the group, 18 ft<sup>2</sup>/sow would be required and for this design 18.5 ft<sup>2</sup>/sow is provided. ESF designs utilize the space very well as evidenced by the GSF of 19.8 ft<sup>2</sup>/sow for this design. Solid penning should be used on dividers between pens that are located in an area with solid flooring. This will help to reduce dunging on solid flooring by eliminating socializing across the open pen partitions.

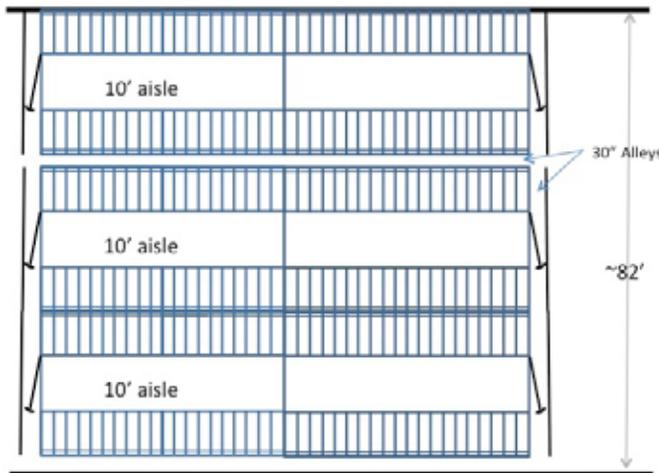
Figure 13 shows an example of a larger group with multiple ESF stations. In this case three ESF stations are used. The solid flooring is divided by partitions to create communal areas to promote usage. The partitions form a barrier for animals returning to the feeder entrance after exiting. This design is shown with a boar pen near the exit which would be placed between two adjacent pens in order to allow heat detection in both pens with one boar. Some ESF systems have boar pens equipped with a sensor to determine which sows have been spending extra time at the boar fenceline, thereby giving an indication of return to estrus. The boar pen

is shown as 8' x 10' and partially slatted. Many systems this size would sort animals that are nearing their expected farrowing date. None is shown in this example. This configuration would not be easily adapted to adding a sorting pen and consideration should be made for dual exit areas.

**Figure 13. Example ESF design for 180 sows shown over a partially slatted floor (8' slats). Solid partitions are added to provide laying areas. A boar pen is shown for heat detection. The NSF is 18.0 ft<sup>2</sup>/sow and the GSF is 19.0 ft<sup>2</sup>/sow.**



**Figure 14. Layout of 6 pens of 40 free access stalls over full slats or specifically designed partial slat new barn flooring. Capacity shown is 240 sows in ~82' x 85'.**



### Reduction of Capacity

Until a complete design is laid out it is difficult to fully determine the loss of sow capacity in transitioning to a pen system. In many cases some traditional stalls will be retained for post-breeding which will minimize the total capacity lost in transition. A modular approach allows comparisons to be made to determine the efficiency of individual layouts. Table 2 provides this information for each of the examples used in the text. NSF represents the net square footage per sow. This is consistent with Table 1 and Figure 1. It should be noted that in the case of FAS and long non-gated stalls that 50% of the stall area is not counted toward the allotted space. GSF

represents the gross square footage per sow, which includes a share of alleys and all the space within stalls. This can be thought of as the “total footprint” of the module within the barn. Capacity loss is a comparison to GSF for traditional stalls. This is an over-simplified comparison but gives some means of benchmarking the space requirements of one system against another. It should be noted that small pens are always less efficient than larger pens because of the difference in space requirement between a small group of mixed sows (23 ft<sup>2</sup>/sow for a group <10) and a large group of pigs (18 ft<sup>2</sup>/sow for a group >40).

A review of Table 2 illustrates that FAS layouts tend to require more space than other choices. This could be, in part, because the assumed FAS was 25.6” x 92.5”. Not all FAS are created equal and stalls that are shorter would be more efficient from a space standpoint, though perhaps not appropriate for large sows. ESF tends to be the most efficient, perhaps because they are always used with larger groups (typically 60 sows/ESF) and all the space is used, including areas that might have previously been alleys. Non-gated and floor feeding appear to fall between

the other systems in terms of space utilization. This comparison is merely based on space and does not consider initial costs, management or performance differences.

**Table 2. Summary of various pen configuration and capacity loss in comparison to traditional stalls.**

Pen Type (Figure #)	Pen Size (sows)	Required Space <sup>1</sup> (ft <sup>2</sup> /sow)	NSF (ft <sup>2</sup> /sow)	GSF (ft <sup>2</sup> /sow)	Capacity Loss
<i>Traditional Stalls</i> (2)	1	---	14	18.5	---
<i>Free Access Stalls (FAS)</i>					
“T” (3)	20	21.3	24.6	34.9	47%
“T” (4)	40	18.0	18.5	29.2	37%
“L” (5)	40	18.0	18.0	27.7	33%
Single Row (6)	20	21.3	23.1	36.6	49%
<i>Non-gated Stalls</i>					
Short dividers (7)	40	18	18.4	21.3	13%
Short dividers (8)	20	21.3	22.4	25.9	29%
Short dividers (9)	60	18	18.1	21.0	12%
Long dividers (10)	20	21.3	25.0	37.0	50%
<i>Floor Feeding</i>					
Small pen (11)	20	21.3	21.8	23.6	22%
Larger pen	40	18	18.1	19.7	6%
<i>ESF</i>					
Small pen (12)	60	18	18.5	19.8	7%
Large pen (13)	180	18	18.0	19.0	3%

Based on mixed parity sows [1] as shown in Table 1 and Figure 1.

## Boar, Gilt Pool and Relief Areas

In laying out a new or remodeled facility the sow spaces are the majority of the need, but other areas are important to make the building function properly. Boar pens, gilt pool pens and relief pens need to not only have adequate space, but the location within the barn is important. Boars may be held in one pen location, such as with an ESF system, or boars may be walked throughout the barn to heat check. Boars should be housed in pens that are at least 8' by 8' [3] and be at least half slatted. In sow pens animals have the ability to huddle if they become chilled but a boar will be solitary and it would be best to avoid a location directly in front of evaporative pads, as that area can chill animals during some conditions. If possible, boar pens should be located down-wind of the majority of sows, especially sows to be heat-checked and inseminated. If sows receive continuous boar stimuli (sight, sound and smell) prior to the time of heat-detection, they may not be responsive to boar stimuli at the time of heat-detection.

Gilt pool pens have different space requirements than mature sows or mixed groups of sows (see Table 1 or Figure 1). Pens of 40 or more gilts only require 15 ft<sup>2</sup>/gilt while pens of 10 or fewer should have 18 ft<sup>2</sup>/gilt. The layout is flexible as long as space requirements are met and feeding is appropriate. Gilts going into an ESF system should be trained for some time prior to entering the herd. This can be provided as is shown in Figure 12 or other layouts suggested by the ESF manufacturer. Gilt training is an important component to the success of sows. Gilts would not likely be placed in FAS because of space and cost associated with the system. However, floor feeding or non-gated stall systems would be good choices. This may be provided in some location within the breeding barn or may be placed in any newly constructed facility and gilts brought into the breeding barn as needed.

The number of relief pens is difficult to determine. Some recommendations indicate that relief pen capacity should be 2 to 5% of the herd. However, this means that for a 2400 sow herd, between 48 and 120 spaces would be required for relief pens. This seems excessive. Perhaps a good tactic is to have several small pens suitable for 6 to 10 sows available to separate out animals needing treatment. These could then be available for normal use when not required. These should be one half to two thirds solid flooring or use rubber mats to help with footing. They should not be placed near the evaporative cooling pad given that animals with compromised health could be stressed further with cool air. In addition, pulling ventilation air across unhealthy animals toward healthy animals might encourage the spread of some diseases. Placing the animals near the center or nearer the fans would be preferable.

## Putting the Modules Together

The previous sections laid out various examples of pen designs that incorporated the basic thought process in converting existing gestation stall barns to group housing systems. The module approach is used and would then need to be fit into an overall building design. If the project will have remodeling components, building width and the flooring system will have the most

influence on choices that can be made. If some traditional stalls are to be kept for post-breeding holding stalls, a decision should be made as to how many and where they will be located. Some producers use one end of a barn as a breeding area, while others may use two or more rows along one side of the length of the barn. Again, this may depend on the type of penning desired for gestation and the pen width required versus what is available. When remodeling, the goal is to best use what you have to reach a good system at an economical investment.

The most common traditional stalled housing systems for breeding and gestation have 6 or 8 rows of conventional stalls and are approximately 60-62' and 80-82' wide, respectively. Flooring designed for flushed manure handling or scrapers are probably most prevalent but some systems are over a deep pit and fully slatted. There are many variations, but the following are two examples of layouts.

## Example Free Access Stall Layout – Figure 14

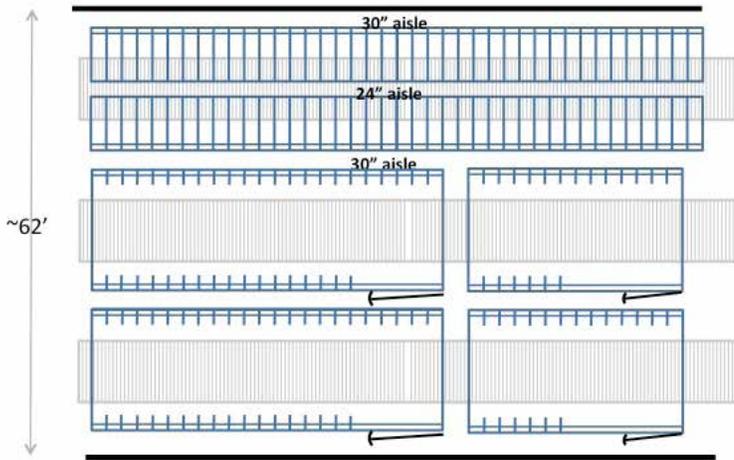
The example in Figure 14 is a building shell that had 8 rows of traditional gestation stalls over a fully slatted floor. FAS stalls were added to create 40 sows per pen in the “I” configuration as shown in Figure 4. This configuration would not work if there had been 8' slats under the rear of the traditional stalls as in some flush or scraper barns. However, a new barn can have slats placed specifically where they are needed so this configuration would work for new construction. The design shown eliminates an animal movement alley on one side of the barn and places two pens back to back, thus only creating two alleys running the length of the barn. With this design there would need to be cross-alleys for animal removal from pens. This makes the system fit within the 82' building width. This option does eliminate the ability to top dress feed thin animals because half the stalls do not have a walkway in front of them. Overall this is a relatively efficient design and uses the available width effectively.

Different width buildings or stalls that are shorter or longer may fit differently. If the width was inadequate to handle this layout, two rows could be converted to a different configuration for the outside row. This “extra” space could be used for relief pens, gilt pens or just a different configuration, such as a single row pen as is in Figure 6.

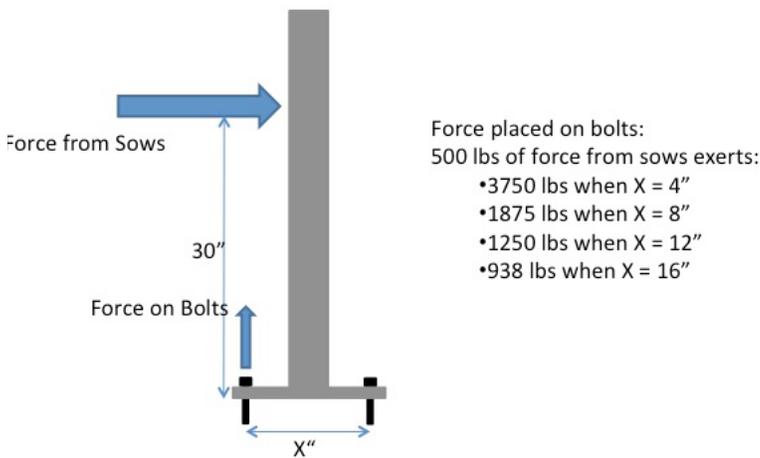
## Example Non-Gated Feeding Stalls- Figure 15

The example in Figure 15 shows how a 62' wide partially slatted flush or scraper barn could be modified. This is probably the least adaptive flooring system and relatively common in some parts of the country. In this example traditional stalls were left in two rows to hold sows during post-breeding. The other rows were modified to create short feeding stall dividers to create pens with adequate space for sows. In the example two different size pens are shown, 20 and 40 sows/pen, to indicate that some small pens may be beneficial for relief pens or for separating out smaller or larger sows. In developing the total building layout heat-check boar pens, relief pens and gilt pens would all be included.

**Figure 15. Layout of non-gated feeding stalls over partial slat flooring. Traditional crates are shown as breeding stalls. Capacity shown is 120 sows in pens and 80 sows in stalls in an area of ~62' x 85'.**



**Figure 16. Illustration of the importance of proper post anchor to the floor. Assumes sows could exert 500 lbs at a height of 30". Bolt force would be divided between multiple bolts on one side.**



### Importance of Anchoring Stall and Pen Posts

Occasional reports have been received on posts that become loose, either from the weight of a gate or from animals pushing on the penning. Anchorage becomes especially critical on long lengths of penning where no lateral support is present because of the lack of corners. Figure 16 illustrates the forces present when animals push against the penning. This force is not well documented, but it would be easy to imagine that two 450 lb sows could push or scratch against a pen divider and exert 500 lbs. This may be at a height of 30 inches off the floor. Because the anchoring bolts are closer together, the torque is translated into a greater force because of a short movement arm. Therefore, if the anchoring bolts were only 4" apart, a bolt tension force of 3750 lbs would be exerted on the bolt (or split between two bolts) on the inside of the pen. As this

anchorage gets further apart the force is reduced such that when bolts that are 16" apart only experience a tension force of 938 lbs. While the force shown may be shared by a second bolt on the inside portion of the pen, the force is still significant and illustrates the importance of proper anchorage. The weight of a gate swinging on a post will have a similar impact.

Some have suggested that fastening posts to the ceiling would serve as a stabilizing factor. However, this changes the loading on trusses and has the potential to cause structural problems and may impact insurance coverage in the event of a roof failure. Avoiding long unsupported pen lengths would be the best solution, although unavoidable at times. Anchoring posts to the slatted floor is much easier accomplished than mounting to solid concrete. Occasionally a bracing frame is added over gates to add rigidity.

### Ventilation Changes

Many times ventilation is overlooked when changing a facility from traditional stalls to a penned system. However, with the changes in animal density it warrants consideration. Leaving the system as-is may over-ventilate in the winter, thereby using extra propane and perhaps chilling animals. During summer the impacts are less pronounced but over ventilation will use extra electricity and, perhaps, not take advantage of the opportunity to capture better cooling performance.

Rules of thumb for gestation facilities are that gestating sows require a minimum ventilation rate of 12 to 16 cfm/sow, depending on size of the animal [3]. To look at the implications of a change we will use an example of a 1000 sow breeding and gestation facility that, upon remodeling, ends up holding 750 sows. If the original design specification was 14 cfm/sow then the original ventilation rate required was 14,000 cfm and the new rate required is only 10,500 cfm. However, there is another consideration. The new layout for the building includes much more airspace per sow and preserving air quality while not wasting extra heat is important. Four to six complete room air changes per hour are recommended for swine buildings to keep air relatively fresh. If, for instance, the 1000 head barn was 60' x 340' with an 8' ceiling, and was to have at least 4 air changes per hour, the calculation would be as follows:

$$\frac{(60' \times 340' \times 8') \times 4 \text{ AC/hr}}{60 \text{ min/hr}} = 10,880 \text{ cfm}$$

Therefore, instead of ventilating at a new rate of 10,500 cfm, the new target rate would be 10,880 cfm. In this case the rates are relatively similar so the difference would not have a big impact, but in some cases if a building holds half of the original number of animals, the "per sow" method would provide insufficient air exchange and lead to poor air quality. The change in this example from 14,000 to 10,880 cfm might mean reducing the number of

fans or replacing larger fans with smaller ones. In this case for instance four 24” fans rated around 6000 cfm might be a good system for minimum ventilation controlled with a variable speed controller. Many larger gestation barns use two fans that are 36” and rated around 10,000 cfm to supply minimum ventilation. Fans larger than 24” are not normally used for variable speed and this conversion may require replacement of fans. Some farms use cycle timers to create the right ventilation “on average”. This method IS NOT RECOMMENDED. When fans are off there is no static pressure and moist air will migrate up through the inlet openings in the ceiling. This condenses on the cold surfaces in the attic and will cause building deterioration. Smaller fans also allow spacing them out to help create more uniform air quality in the barn.

Another consequence of over-ventilating is energy costs. If ventilation continued at the pre-remodeling level, the building would be over ventilated by one third. An estimation of energy use for an over-ventilated wean to finish facility indicated that over ventilating by 30% can raise heating energy consumption by 75%. [10] For gestation facilities this is probably an overestimation but a safe assumption would be that if no change is made in ventilation, propane usage will go up significantly.

Summer ventilation may be left as-is since too much ventilation air in summer is not necessarily a bad thing. The rule of thumb is 300 cfm/sow without evaporative cooling and may be reduced when cooling is used. [3] Industry standards use 225-250 cfm/sow for evaporative pad barns. Evaporative pads normally work best when the air speed through them is slow enough to be cooled by evaporating water. The ideal air velocity through the pad varies with pad type but a good goal is 250 fpm, or in other words, there should be 4 ft<sup>2</sup> of evaporative pad for every 1000 cfm of ventilation. For our example the summer ventilation rate should have been approximately 250,000 cfm to start with (1000 sows @ 250 cfm/sow) and the reduced capacity of the building would make 187,500 cfm (750 sows @250 cf/sow) the new target. This reduction may be the equivalent of about three 48” fans that could be turned off to save energy. If the evaporative pads had been undersized previously, reducing the total ventilation may actually improve cooling by allowing the air to move more slowly through the pad and evaporate more water, thereby lowering the incoming temperature further. The proper environment is paramount and remodeling or new construction is a good time to evaluate the ventilation system. Seek guidance from a qualified agricultural engineer.

## Accomplishing Remodeling During Production

Ultimately, most systems will need to add space if they are to keep the same pig flow through the system. Typically there are two approaches to addressing this, either a building can be added onto or an additional building can be constructed and tied into the system. Adding a new building first provides many options and also allows for “flex space” during remodeling by providing the opportunity to fill the new building and then start remodeling an existing one. A new building can be isolated from a

biosecurity standpoint to make it easier to bring in equipment and allow construction workers to enter the site without showering. Remodeling can then be done a pen at a time to minimize the loss of space. However, this offers challenges because of biosecurity protocols. Equipment will need to be cleaned and brought into an active system. Tools will need to be disinfected as they are brought in and workers will need to shower in.

Adding onto an existing building provides challenges as well. Normally space would be added to the end of a building where the new building shell would be constructed with the endwall remaining in place until time to unite the addition with the rest of the building. The building may have to remain open during a portion of the construction which provides challenges for ventilation, because an unsealed building can build no static pressure and eliminates air distribution. In addition, biosecurity is compromised because birds or pests may be able to enter. If the completed building becomes too long, ventilation will be less effective. It may also complicate the manure handling system, whether a deep pit, flush or scraper building. In most cases, adding onto a working swine facility is a more difficult challenge than building a new, smaller building as an addition to the farm. Additions may be just as expensive as a new building.

One important aspect of remodeling or new construction is compliance with state regulations. Remodeling within the building may not require permits. Adding additional spaces in either a new building or increasing the size of a current building may require approval, even if the number of animals will not change. This is an important consideration and should be checked with local authorities.

## Summary

There are many considerations when transitioning from a traditional stall barn to a group housing system. This paper has attempted to lay out the thought process of converting a building, including the options of free access stalls, non-gated stalls, floor feeding and electronic sow feeders. The best system may have a combination of several of these options. Boar space, relief pen space and gilt pens should be a part of the consideration. The layouts within this paper are merely examples and many other possibilities exist. Use actual equipment dimensions in designing your project. Special attention to animal access and flow, pen post mounting and required ventilation changes are important. Above all, time should be taken to painstakingly plan the pig flow needs and developing a system that will meet your needs. Proper attention to planning details will avoid many of the pitfalls that can occur while creating the proper environment for sows at an economical price.

Disclaimer: Reference to commercial products or trade names is made with the understanding that no discrimination is intended of those not mentioned and no endorsement by the authors or National Pork Board is implied for those mentioned.

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