

Development of an innovative group feeding system for gestating sows



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Report

Sébastien Turcotte¹

Marie-Aude Ricard¹

Alain Lefèbvre²

Jennifer Brown³

1 Centre de développement du porc du Québec inc.

2 Jyga Technologies inc.

3 Prairie Swine Centre



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du porc du Québec inc.

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Production team

Team Leader: Sébastien Turcotte, Agr., (CDPQ)

Project Leader: Sébastien Turcotte, Agr. (CDPQ)

Collaborators: Marie-Aude Ricard, Eng. (CDPQ)
Alain Lefebvre, (Jyga Technologies inc.)
Jennifer Brown, Ph. D., (PSCI)

Authors: Sébastien Turcotte, Agr., (CDPQ)

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1 Introduction

Animal welfare now has an influence on marketing rules in Canada. Major pork producers and processors in Canada (Maple Leaf) and the United States (Smithfield Foods) pledged in 2007 to convert their gestation rooms into sow group housing by 2017 (Brown, 2012, personal communication). In Europe, individual gestation stalls have been prohibited since January 1st, 2013 (Poulin and Forest, 2012).

In 2012, a growing number of Canadian restaurants, like Tim Hortons, Burger King and McDonald's as well as Safeway, have committed to sourcing from producers whose gestating sows are housed in groups. More recently in 2013, the Retail Council of Canada, made up of eight of the major supermarket chains, namely Walmart Canada, Costco Canada, Metro, Loblaws, Safeway Canada, Federated Co-operatives, Sobeys and Atlantic Co-op, who collectively account for 90% of retail grocery sales in Canada, decided to only buy pork from suppliers offering an alternative to sow housing in gestation stalls, and will implement this as early as 2022. Furthermore, Olymel, the biggest pork processor in Canada also announced that it wanted to buy only hogs from sows housed in groups as of the same year. So even if the transition from housing sows in stalls to housing them in groups is not legislated in Canada, the market currently dictates the rules that must be followed.

In 2012, Canada exported more than 99 M\$ of pork to Australia (6th most lucrative client) and 981 M\$ of pork to the United States (our biggest client) (AAC, 2013) and in these two countries, sow group housing is a growing trend. Our producers who sell to these markets will have to quickly convert their buildings if they do not want to lose these lucrative clients.

All Canadian producers must comply with the Animal Care Assessment (ACA) program requirements, which have been included in the Canadian Quality Assurance (CQA) program since January 2012. Also, a draft of the new Code of practice for the care and handling of pigs was made public on June 1st (NFACC, 2013). This new Code is based on the ACA program and suggests several significant changes. The main change is the requirement to provide group housing for gestating sows. This measure could become effective as of July 1st, 2014 for all new construction and renovation projects. Also, it could become mandatory for all producers as of July 1st, 2024.

To comply with these new requirements, producers will have to renovate their buildings or build new ones. Although, the difficult economic situation could complicate the process. Existing buildings are not suitable to accommodate sow group housing without undergoing major renovations. A project conducted in the summer of 2012, by the CDPQ, (Pouliot *et al.*, 2012) found that major investments would be required to convert existing buildings into sow group housing (\$850 to \$1,200/sow). Very different herd management can also be expected. With this level of investment, a new herd management plan must be functional as soon as it is implemented in order to avoid financial difficulties. There is a significant risk that animal performance and welfare could be affected if the transition is mismanaged (Brown, 2012, personal communication).

Given the large number of options regarding layout and feeding systems for sow group housing as well as the lack of experience and practical information on the subject in North America, farmers are undecided and hesitant to venture into changes to their buildings. However, the transition to keeping gestating sows in groups is a crucial step for the future success of Quebec and Canada's swine industry, in order to ensure, maintain and improve access to domestic and international markets.

1.1 Objectives

The objective of this project is to develop a system for feeding and housing gestating sows in groups, adapted both to small farms or larger ones, and with individualized sow feeding at a lower cost.

To do so, this new system combines two existing technologies; the Gestal feeding system (Figure 1) and free access stalls (Figure 2) which must be adapted for this particular application.



Figure 1 Gestal feeding system for lactating sows



Figure 2 Vissing Agro self-locking feeding stalls used in various tests

The adaptations required are, among others:

- Adapt the Radio Frequency Identification technology (RFID) to the Gestal system;
- Develop computer and electronic systems that will allow the Gestal feeding system to operate automatically and to configure the desired feed settings for each sow housed in the group;
- Develop the Gestal system's artificial intelligence based on this application;
- Develop a way to prevent sows from staying in feeding stations too long;
- Adapt feeding stalls to this type of special use
- Identify setup and optimal design parameters for this new concept.

Despite the fact that the two existing technologies need to be adapted, there are several uncertainties with this new technology:

- Sow feeding behaviour of sows;
- The average time a sow spends per day in a Gestal feeding station
- Optimal number of sows per feeding system;
- Sow behaviour depending on the equipment setup within the pen.

Thus, this system will be developed to be as comprehensive as possible. The important points are:

- To obtain an individualized diet which will allow to control the sows' body condition;
- To protect sows during feeding so as to promote their health and well-being;
- Have an efficient system, regardless of farm size;
- Be simple to understand and operate;
- To significantly reduce investment costs compared with other individualized feeding systems available on the market.

2 Equipment Development

2.1 The feeding station equipment

The Gestal feeding station for sows in group housing consist of a free access stall and a Gestal Solo system, both modified for sow group housing.

2.1.1 Free access stalls

Sows can only enter if the feeding stall is opened (Figure 3 a). When the sow enters the stall, it must push and lift a metal part, located at about two feet from the feeder, with its head (Figure 3 b). This closes the door behind the sow (Figure 3 c). Thanks to its automatic locking mechanism (Figure 3 d), the door cannot be opened by other sows.

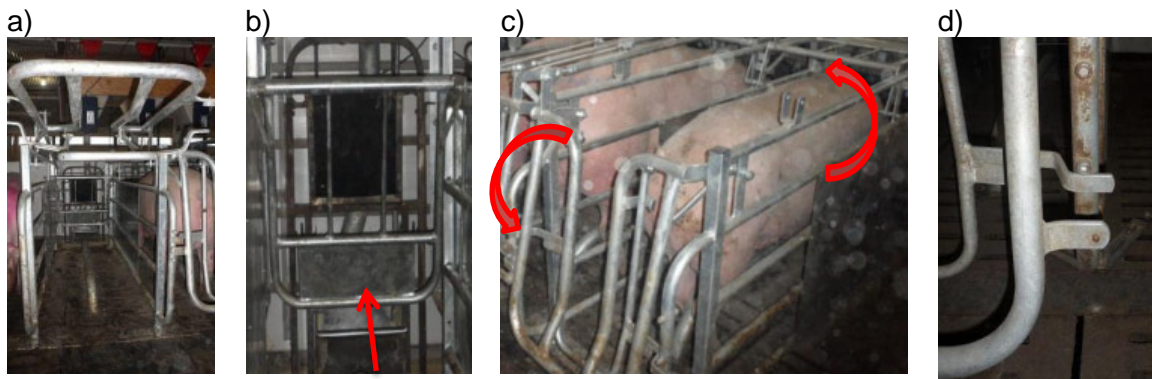


Figure 3 Sequence of actions to allow a sow to enter the feeder

To exit the stall, the sow only has to back into the double-door mechanism which unlocks and allows it to be opened (Figure 4).



Figure 4 Sequence of actions to allow a sow to leave the feeder

2.1.2 Modified Gestal system

Each feeding station prototype (Figure 5 c) is equipped with an antenna, which allows for sow identification (Figure 5 a), a feeder (Figure 5 a) and a Gestal system with a supply of feed (Figure 5 b) that distributes the feed.

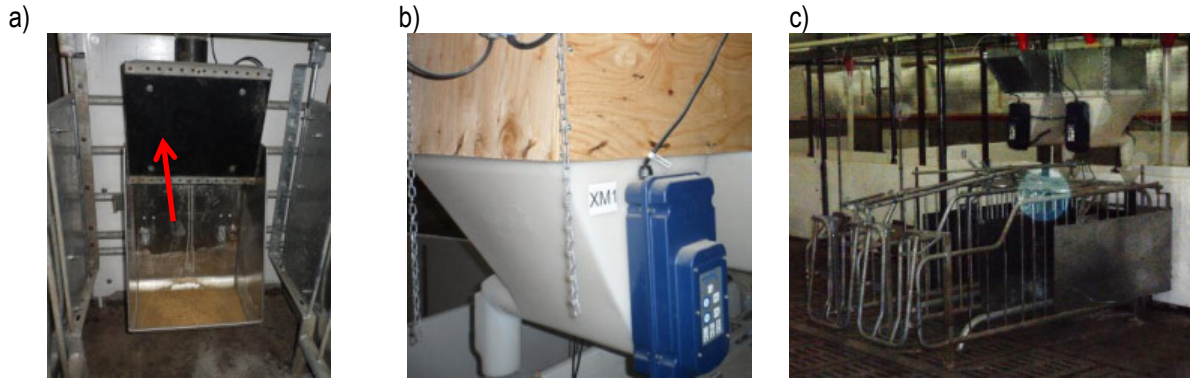


Figure 4 a) Antenna on a feeder b) Gestal system with feed c) prototype of a Gestal Dynamix G station

2.2 Adapting RFID to the Gestal System

2.2.1 Using commercial electronic tag readers

All tests in this project were done using commercial electronic tag readers in order to accelerate equipment development and advance faster to on site farm testing (Figure 6). On the other hand, given the high cost of this equipment, Jyga Technologies Inc. decided to develop its own antenna for sow tag reading.

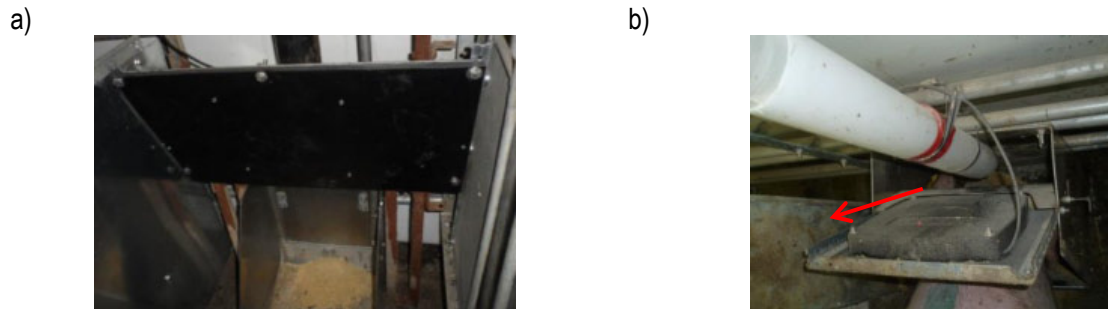


Figure 5 Commercial antenna used on prototypes: a) front view, b) rear view

2.2.2 Developing an electronic tag reader system

Alongside farm tests, Jyga Technologies Inc's engineering and computer technology department worked on the development of an electronic tag reading system to reduce the final cost of feeding stations. These new antennas were not tested in this project.

2.3 Development of computer, electronic and communication systems for the feeding system

Jyga Technologies Inc's engineering and computer technology department was responsible for developing the different computer systems, the software for the new feeding system, designing various electronic and mechanical components as well as developing the artificial intelligence and the system that allows communication between stations and the main Gestal system

computer. Their excellent work allowed the creation of a functional, reliable, durable, easy to use supply system that enables individual feeding of each sow in a herd.

2.4 Development of the factory prototype

A first prototype was produced in a factory (Figure 6). Its purpose was to ensure that the different electronic and mechanical components of this new supply system worked together (antenna, computer system and feed distribution mechanism). Several trials and adjustments were made to ensure that it is functional and reliable and to avoid a situation where sows would not be able to feed because of a mechanical or electronic failure, which would compromise their well-being.



Figure 6 First prototype assembled in a factory (antenna and feeding system not assembled on this picture)

3 On farm prototype testing: small scale

3.1 Layout of the room

The first farm test took place in a former maternity in Saint-Isidore owned by Ferme Aldo. A small room, 14 ft 6 in by 26 ft which, according to the new Canadian Code of Practice for the Care and Handling of Pigs (NFACC, 2013), may hold a maximum of 20 sows (19 sq. ft/sow) was used to carry out tests on four sow groups (Figure 7 and Figure 9).

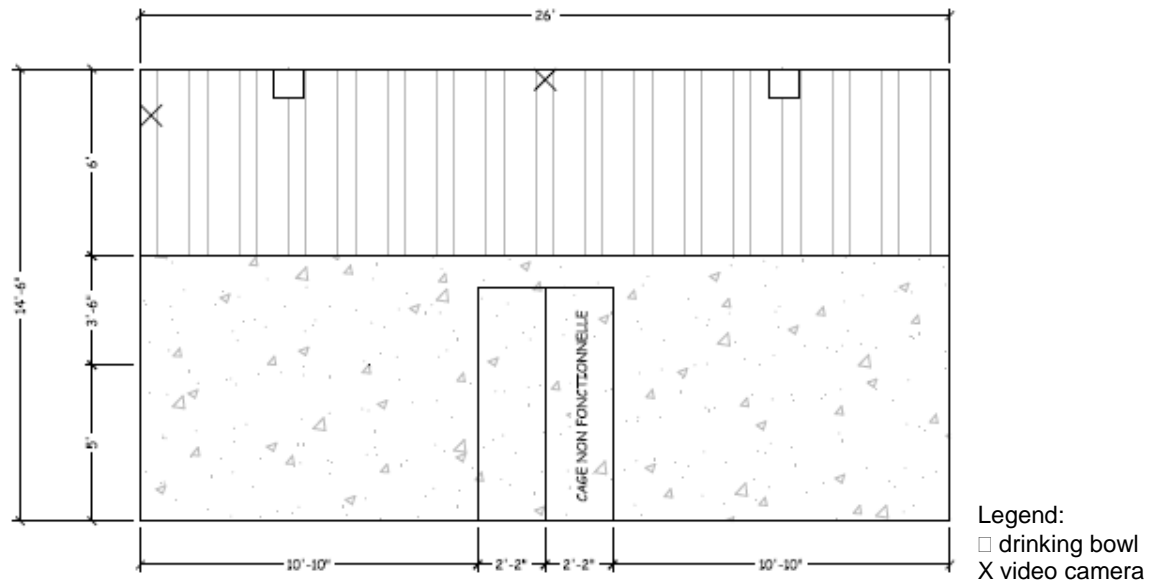


Figure 7 Plan of the room where the first test was performed



Figure 8 Room where the first tests with cull sows took place

The layout of this room was not optimal, because the distance between the feeding stalls and the back wall (6 feet 10 inches) was not wide enough to allow easy circulation for sows within the pen. In addition, the lack of space and poor planning of this room did not permit tests with two existing feeding stalls, so the first four sow groups were fed with a single stall.

In this room, there were two water bowls, which respects the ratio suggested by ITP (2001) for sow groups, that is to say one bowl for 10 to 15 sows when the feeding system does not distribute water.

Two cameras were installed to continuously film the sows and better understand their behaviour in this new feeding system and within this pen layout.

3.2 Tests

In this room, several tests were performed on four separate sow groups. In each of the tests, cull sows from Ferme Aldo were used. Several tests and adjustments were made during this period (Table 1).

Table 1 Tests and small scale adjustments carried out on four sow groups

Sow group	Test dates	Number of sows at beginning of test	Tests and adjustments made
#1	May 28-June 25	12	<ul style="list-style-type: none"> • Individual feeding of sows in group • Several anti-sleeping bars • Training of sows • Testing of several types of tags • Determination of occupancy time
#2	June 25 -July 24	15	<ul style="list-style-type: none"> • Individual feeding of sows in group • Training of sows • Testing of several types of tags • Determination of occupancy time • Analysis of sow feeding periods
#3	August 7 - 28	15	<ul style="list-style-type: none"> • Individual feeding of sows in group • Self training of sows • Observation to determine a training strategy
#4	Sept. 25 - Oct.11	14	<ul style="list-style-type: none"> • Individual feeding of sows in group • Observation to determine a training strategy

3.2.1 Individual sow feeding within a group

The first observation was that the new feeding system can feed each sow individually. It is also able to identify a sow that has already eaten its daily ration and ceases to feed it for the rest of the day.

Since it is the first version, the full feed ration for the sow is distributed when the system identifies it. On several occasions, a sow left the station without having eaten its full ration. In this case, the next sow to enter the station eats the previous sow's ration in addition to its own. To avoid this situation, the next prototypes will divide the sow's ration into small feed portions so as to make sure that the feed distributed is fully consumed by the identified sow. The system will then have to re-identify the sow in the feeding station before giving her more.

3.2.2 Components to avoid sows spending too much time in the station: Anti-sleeping bars and lack of water

In this system, sows have no incentive to get out of the feeding station as is the case with electronic sow feeders. With this feeder, when a sow has finished her ration, the station gate opens and the sow inside is driven out of the station by the next sow that wants to feed. This approach enables an ESF system to feed, on average, 60 sows.

In the new Gestal feeding system for sow groups, a combination of two elements were tested to avoid sows staying in the stall for too long; the use of anti-sleeping bars and giving sows dry feed without water. The first prevents the sow from lying down in the stall. Since sows are protected when they feed, they would be tempted to stay inside the stall and not be disturbed by others. Three types of anti-sleeping bars were tested in the feeding station during this on farm experimental phase (Figure 9).

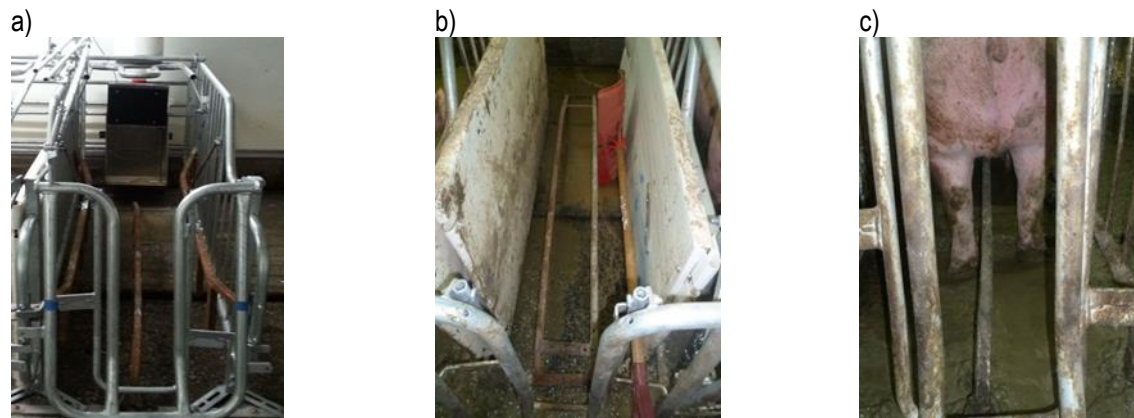


Figure 9 Three types of anti-sleeping bars were tested: a) Combination of simple anti-sleeping bar and anti-crush bars on the sides; b) double anti-sleeping bar; c) single anti-sleeping bar;

The combination of a single anti-sleeping bar and anti crush bars (Figure 9 a), which is usually used in farrowing crates to reduce piglet crushing, prevents sows from lying down in the feeding station. On the other hand, its features restrict the sow movement making it difficult for them to move in the station. The same phenomenon was observed with the use of a double anti-sleeping bar (Figure 9 b). The use of a single anti-sleeping bar without anti crush bars on the sides (Figure 9 c) turned out to be very effective, because it prevented sows from lying down inside the stall and didn't hinder their entry and exit from the feeding station. This is what will be used for the next prototypes.

The second element to ensure that sows will not remain for too long in the feeding station is the use of dry feed without water. The lack of water forces sows to leave the feeding station once they have completed eating their ration or even prior to that. The disadvantage of this strategy is that sows consume dry feed slower than when they consume wet feed (Caille, 2011). However, according to Jennifer Brown (personal communication), the time spent in stations in which there is water, intended to increase the speed of ingestion, should be higher even if the sows eat faster. This would be due to the fact that sows feel safe in the station and since they are less thirsty, remain longer.

3.2.3 Electronic tags

The International Organization for Standardization (ISO) for identifying livestock by radio frequency established that the use of the 134.2 kHz low-frequency band is the standard to be met. This frequency can be read in extreme humidity and dirt, and even under these conditions, it provides a well-defined reading area for animals that pass next to the tag reader.

There are two types of chip on the market, either HDX (Half Duplex) and FDX (Full Duplex) chips. Electronic identification systems capture the ID number of an animal through an exchange of electromagnetic waves between a reader and a transponder integrated in the tag. The reading of the information is secure.

In general, HDX technology allows the greatest reading distance while FDX technology offers a somewhat reduced performance but at a lower initial cost. In addition, last September, Canada ruled that only FDX chips can be used for traceability purposes (CPC, s.d.).

Five different chips were tested in different trials (Figure 10). Tags numbered 1, 3 and 4 are FDX prototypes from different companies, and provided a base for research and development. We are not allowed to disclose their source. Electronic tag number 2 is an AllFlex HDX. It was not used on the farm, because the antenna prototypes only read FDX technology. However, it was tested on the antenna developed by Jyga Technologies Inc..



Figure 10 Tags tested with the Gestal RFID

Tag number 5 is the one that was used most during the on-farm trial. It's an FDX Destron tag. In addition, this loop seems to be the strongest, because the sows that got this tag did not lose it as much as the others during testing.

Reading distances of the four FDX tags are very similar at approximately 18 inches, on average.

3.3 Results of the first tests

3.3.1 Training the sows

Training the sows to go feed was a challenge for the first four groups tested. It has been demonstrated that only about 5% of parity 4 (or higher) sows who have spent their lives in a stall do not acclimate to group housing with ESF systems (antisocial behaviour and do not understand the feeding system), these sows are usually culled (Caille, 2011). The new supply system which was developed in this project can be compared to an ESF system because in both systems sows need to learn how it operates to receive their daily ration. Sows must go to the station to feed and the system is based on an individual feeding principle that requires feeding them one after the other, rather than feeding the entire group simultaneously.

In the first two tests, the recommended training strategy was to let sows by themselves for the first 48 hours before acting and bringing sows that hadn't eaten into the feeding station. Subsequently, those who spend more than two consecutive days without feeding suffered the same fate. The results obtained in these two groups were very similar and are as follows: after

two days in this new system, approximately 67 % of sows fed themselves. This proportion had increased to 75 % after five days, 92 % after seven days and 100 % after 14 days.

The training strategy used during the third and fourth tests was to reduce human intervention to see if sows were going to learn how to use this feeding system by themselves. The learning speed was very similar to the first tests.

However, unlike the first groups where all sows remained until the end of the test, two sows from these groups had to be withdrawn for reasons related to their diet.

Observations on the third and fourth sow groups permitted to decide on a strategy that facilitated training. During the first days after group training, it was noted that sows that had never entered the feeding station gravitate around it because they can smell feed. They continue this ploy for 5 to 10 minutes and then, not knowing how to feed, they go lie down. This scenario was repeated several times when another sow entered the station and feed was distributed.

So to make learning easier for sows, a pen with several stations was tested. Pigs are gregarious animals and learn by imitation. So, if there are several stations in a same pen, the chances that a station be free are much higher. When a sow gravitates around a station to try to feed and sees other sows feeding, it will be able to enter a free station and feed.

3.3.2 Time spent in the feeding station and occupation periods

Knowing the time spent in the feeding station is essential in determining the maximum number of sows that can be fed per station. To avoid increasing stress within a sow group, it is recommended that all sows in that group feed in less than 16 hours (Pig Research Centre, 2012).

The time spent in the feeding station can vary greatly from one day to another and one sow to another. The average time each sow spent in the station per day was analysed in groups 1 and 2 and is respectively 50 and 45 minutes (Table 2). This is the time spent when there is only one feeding station in the pen and includes all visits of all sows, even visits where they were not fed. So in theory by observing the recommendations of the Pig Research Centre (2012), a Gestal station could feed up to 19 sows (16 h/50 min/sow).

Table 2 Occupation of the feeding stations during the first three tests in the small room.*

Test (Group)	1	2	3
Group size	12	15	15
Sow feeding alone (%)			
2 days after training the group	67		53
5 days after training the group	75		73
7 days after training the group	92		87
14 days after training the group	100		100**
Average occupancy time (min/sow/day)	50	45	na
Average occupancy rate (% day)	30.3 ± 43.5		na
Average number of visits (visit/sow/day)	3.2 ± 2.2	2.2 ± 1.4	na

* No results available for the 4th

** Two sows were removed from the trial because they never understood the system

The number of visits per sow per day varies from one sow to another and from one day to the other. Some sows will go only once a day and others, on average, more than six times per day. The maximum number of visits recorded per sow in the same day is 11. In the first two sow groups, the average number of visits per sow per day was 3.2 (± 2.2) for group 1 and 2.2 (± 1.4) for group 2 (Table 2). As with the ESF system, the attendance order is practically the same every day once the hierarchy is well-established. Dominant sows are the first to eat while dominated sows are the last. Also, in both groups, the dominant sow was the one who visited the feeding station more often per day and was the one that remained the longest in the station. For example, in Group 1, the dominant sow was in the station 5.3 times per day with an average daily occupancy time of 135.4 min; this is the highest data for this group. Same observation for the second group; the dominant sow averaged 4.4 visits to the station and spent an average of 97 minutes per day in the feeding station.

The amount of time spent in the feeding station can vary greatly from one day to another and one group of sows to another and depends on the time of day. The average occupation rate of the station for groups 1 and 2 was 30.3 % ± 43.5 % for an average of 13 sows (Table 2). To comply with the recommendation of the Pig Research Centre, the occupancy rate could be as high as 66 % (16 hours of occupation over 24 hours).

The change of day was at midnight, which means that from that time, sows were entitled to receive their daily ration. The occupancy rate (Figure 11) was over 40 % from midnight to 7 o'clock in the morning and lower for the rest of the day except at two peak hours, first at 4:30 p.m. and second at around 22:30 p.m. The first peak was when the automatic feeding system, which automatically fills the feeder with feed, started up. We did not find explanations to the increase in station occupation at around 22:30 p.m. Further work would be needed to really understand feeding behaviour of sows in groups with Gestal feeding stations.

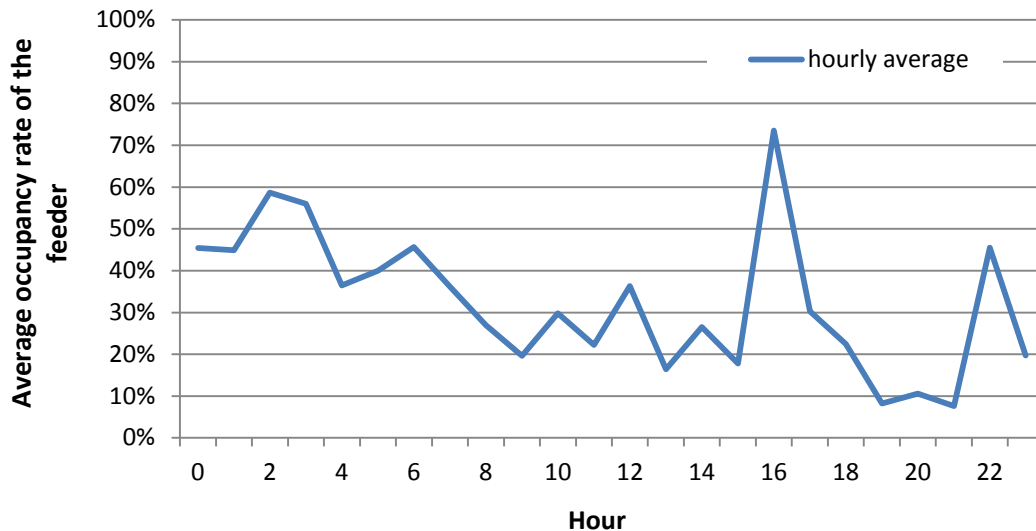


Figure 11 Average occupancy rate of the feeding station during testing for groups 1 and 2 depending on the time of day

3.3.3 Observations of sow behaviour within the pen and in and around the feeding station

Observations made during the first small scale trials allowed to better understand sow behaviour and better plan subsequent tests.

As with all other systems for the sow group housing management, there were a few tussles during the group’s creation. These fights lasted a few hours, until the group hierarchy was established. The small group size (less than 15 sows) and the pen configuration did not allow the dominated sows to flee and, therefore, they had to confront the dominant sow. Also, the use of cull sows that spent the majority of their lives in a stall increased the difficulty of adapting to their new life in a group. These sows had not learned how to behave and interact with their congeners, having been confined in a stall throughout their adult life. According to Dr. Parsons (personal communication, 2013) the socialization of sows at a young age (towards the end of fattening) reduces the intensity and number of altercations in training groups.

Once the hierarchy is well-established in the group, we faced the fear that sows would have trouble exiting feeding stations. Since the sows had been in a stall for all their adult lives, we thought that they would not be able to exit the feeding station on their own. This fear proved unfounded. All sows learned very easily how to exit the stations by backing up, even if they were rather shy and careful the first few times they did it. The fact that they cannot lie down and that there is no water in the station entices them to exit fairly quickly.

The lack of space in front of the feeding stations and the fact that some sows slept before them led to anti-sleeping bars being installed in front of the feeding stalls (Figure 12). Adding this device was not conclusive because sows still slept in front of the stations, which interfered with the flow of activity within the pen. Also, adding this equipment in the area where sows moved around increased the risk of a leg injury. Therefore, it was agreed that it was possible to do without the bars in an adequately developed pen where space in front of feeding stations is sufficient (minimum 11 ft; 6 ft serving as resting space for sows and 5 ft used for activity). This way, sows lying before the stations do not impair circulation within the pen.



Figure 12 Anti-sleeping bars in front of feeding stations and sow leaning on the wall in front of the feeding stations

Some aggressiveness was observed at the entrance of the Gestal stations when determining which sow got to enter next into the station. Also, on a few occasions, we observed two sows who tried to enter the station at the same time (Figure 13). Similar aggressiveness was also observed with the ESF system. Increasing the number of stations (two or more instead of only one) in the pen is expected to decrease occurrences of this behaviour.



Figure 13 Altercation between two sows at the entrance of the feeding station

Also, we observed on several occasions that a sow in the station did not lock the stall door and got disturbed (Figure 14). To lock this door, sows must push and lift a metal plate which tips and locks the door behind it. If the sow does not fully raise this plate or a sow in the pen prevents it from doing so, the sow inside the station gets bothered by the others (nipping or pushing at its hindquarters, hit on the head with the metal plate). What is surprising is that sows in the stall continue to feed and do not seem to be bothered by these inconveniences.



Figure 14 Sow feeding in the station that did not lock the door

4 On farm prototype testing: large scale

Observations made using the first small scale prototypes allowed to better understand sow behaviour with this new feeding system and better plan for subsequent tests.

These larger-scale tests took place on the same farm, but this time in the gestating section which was completely renovated.

4.1 Changes to gestation stalls for sow group housing with the Gestal group system

The first stage of the transformation was to dismantle all the equipment contained in the gestation room: gestation stalls, pen divisions, dispensers, feed containers and automatic feeders. Subsequently, the stainless steel drinkers were also removed. The concrete was then redone under the drinkers to obtain a flat surface.

The next step was to block the manure slides that were on the concrete gestation slats. This was achieved using long metal plates and stainless steel rivets designed specifically for concrete (Figure 15). The use of rivets rather than «U-bolts» allows for a much smoother floor surface and decreases the risk of leg injury since there are no bolt heads sticking out from the metal plate.



Figure 15 Use of stainless steel rivets and long metal plates to seal the manure slides of the gestation slats

Once work on the floor was finished, the equipment (Gestal feeding stations, anti-sleeping bars, automatic feeder and drinker) and PVC pen divisions were installed (Figure 16). To ensure the strength of pen divisions between rest areas, the poles used to hold them were anchored firmly to the floor and ceiling.



Figure 16 Equipment, PVC pen divisions and poles used to hold them securely

4.1.1 Layout of the training pen

The training pen is nearly 39 ft long by 20 ft wide. It has three resting areas of various lengths (Figure 17 and Figure 18).

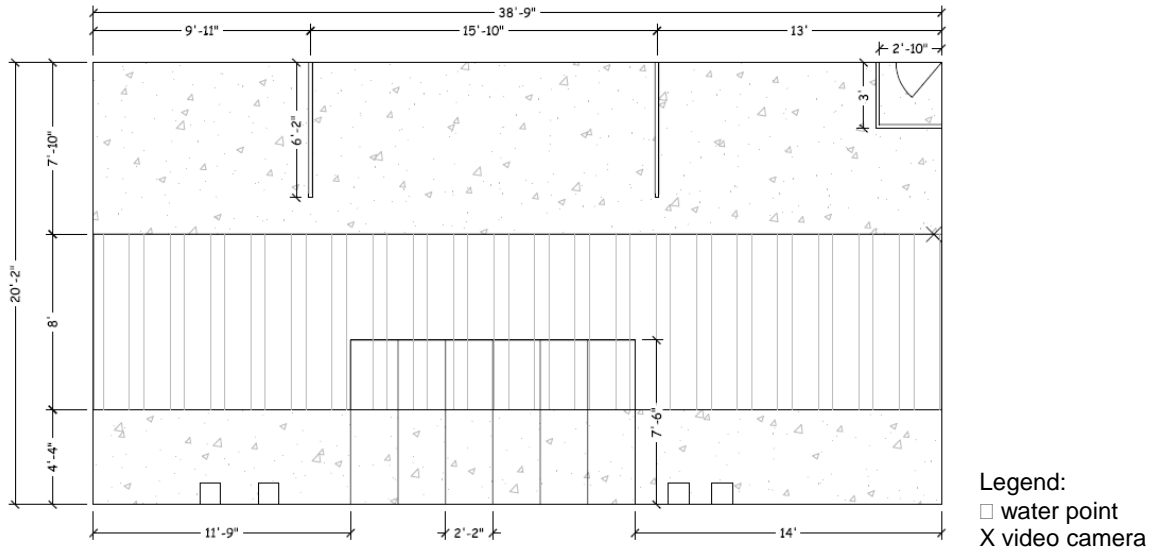


Figure 17 Layout of the training pen at Ferme Saint-Isidore



Figure 18 Layout of the training pen

Six stations were placed in the middle of the pen, along the center aisle. In addition, four water bowls were installed on each side of the Gestal stations. The distance between the back of the feeding stalls and the wall was 12 ft, 8 in. The floor was slatted for a width of 8 ft in the centre and was full on both sides (Figure 18). The floor was left as is, aside from metal plates that were installed to plug the holes in the manure slide that was part of the existing gestation slats.

4.1.2 Sow pen layout

The sow pen layout was similar to that of the training pen, but the dimensions were somewhat different (Figure 19 and Figure 20). However, this pen had only two feeding stations instead of six.

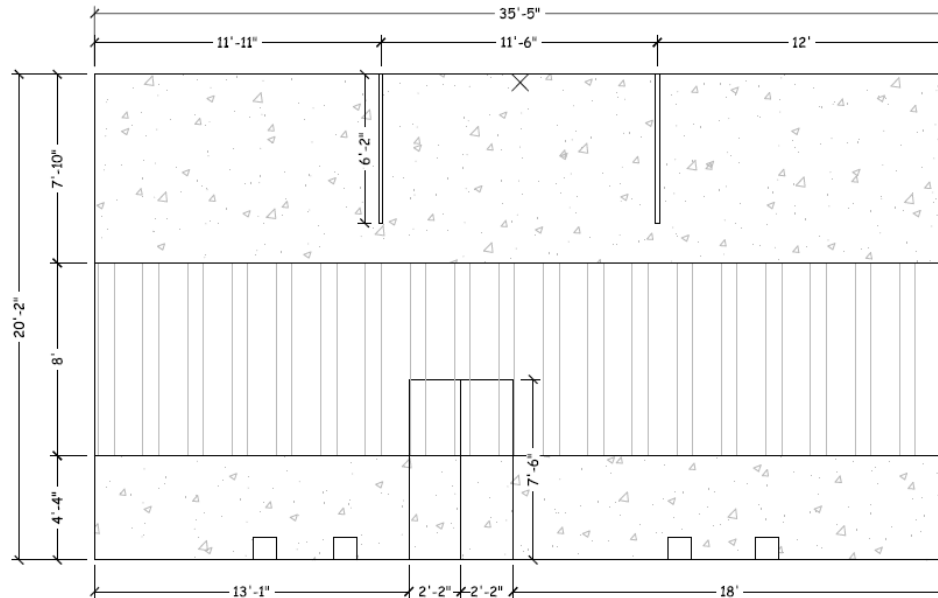


Figure 19 Layout of the gestating sow pen at Ferme Saint-Isidore



Figure 20 Layout of the gestation pen at Ferme Saint-Isidore

4.2 Changes to the second generation prototype

Thanks to the observations made in the first test, changes were made to the prototype during the improvement process.

In the new prototype, the backs of the feeding stations are higher than in the first prototype, which better protects the sow inside and prevent those outside from disturbing it (Figure 21). Also, the metal plate is larger, increasing the sense of security of the sow inside.



Figure 21 a) New stall, b) previous model

In addition, a new, bigger and streamlined anti-sleeping bar, which reduces the risk of injury and ensures that sows do not lie down in the feeding station, was tested (Figure 22).



Figure 22 New second generation prototype anti-sleeping bar

4.3 Results of larger scale tests

4.3.1 Training the sows

To facilitate the sows learning of this feeding system, the training pen has several feeding stations (6) and can contain a maximum of 40 sows (area of 19 sq. ft/sow). This is a ratio of 6.7 sows per feeding station.

The chosen training strategy was to minimize human intervention and let sows learn how the stations work by themselves.

Of three sow groups (a total of 86 sows) tested with this strategy, only one sow did not understand the system after five days in the pen while all the others had fed at least once. This training pen strategy, with multiple stations, seems to work very well. To improve the success rate and learning speed, it would be good to intervene amongst sows that have not fed after two or three days in the pen and make them enter the stations.

4.3.2 Meals dispensing in small feed portions

Dispensing the meal in small feed portions consists in distributing the daily ration as several small subsequent meals until the sow has received its entire daily ration. The logic behind this concept is that the feeding system has to re-identify the sow in the stall before giving it another portion of feed. This helps increase accuracy in feed distribution, avoids waste and ensures that the feed goes to the right sow. However, it is preferable that sows eat all of their ration in a single presence in the feeding station so as to reduce traffic and occupation time of the feeding stations.

To do this, two parameters can be adjusted by the breeder; the amount of feed given per dose (adjustable starting at 50 grams) and the time between doses. With ESF systems, it is recommended that the time between doses be similar to a sow's ingestion speed. It is important to know that the ingestion speed of sows varies with age and that gilts usually eat slower than sows.

If the time between two servings is too short and the sow doesn't have time to eat all of the first serving, the feed accumulates in the bottom of the feeder, which may increase waste and decrease the feeding accuracy when a sow leaves the station before finishing the ration. When that happens, the system indicates consumption greater than what the sow actually ate, because the system assumes that the feed it distributed is entirely consumed by the sow.

Inversely, too long a time between two feed portions can frustrate the sow and cause it to leave the feeding station. In this case, the sow will visit the feeder several times to consume its entire daily ration.

Even if dispensing the meal in small feed portions did not affect each sow's feeding time, it is a very important factor to consider for the reasons previously mentioned.

4.3.3 Occupation periods and time spent in the feeding stations

The average time spent in the feeding stations per sow per day in pens with more than one feeding station and with adequate pen management is much less than those obtained in the first tests. In fact, it varies from 19 to 37 min in the eight sow groups that were analyzed and averaged 30.1 min per sow per day compared to 45 and 50 min in the first tests. The average time sows spent in the stations in the training pen was 26.1 min per sow per day and in the sow pen, 32.9 min.

Following the recommendation of the Denmark Pig Research Centre (2012) that all sows should take less than 14 to 16 hours to feed with ESF systems, a feeding station could feed up to 29 sows (16 hours / 36 min).

In the different larger scale tests conducted (8), the maximum ratio that was tested is 21 sows per station. No problems were observed (aggressiveness in front of the stations or increased injuries). Additional tests would be needed to determine the maximum number of sows that can be fed by a feeding station.

The average occupancy rate was lower in the training pen (43.9 % \pm 35.7) than in the sow pen (55.1 % \pm 35.7). This is due to the fact that there were four more stations for the same number of sows. The stations in the two pens were slightly more occupied in the morning than in the afternoon, until about 7:00 p.m. In both pens, the stations experienced occupation peaks between 7 pm and 10 pm (Figure 23). We are unable to explain this increase. It is not related to feed distribution because, in this section, the automatic feeder worked six times a day at four

hour intervals. On the other hand, there were pigs in growing and finishing, housed in pens in front of and next to the sows. The sows' behaviour was perhaps influenced by pigs in growing and finishing. More work should be done to better understand sow feeding behaviour in a group fed with Gestal feeding stations.

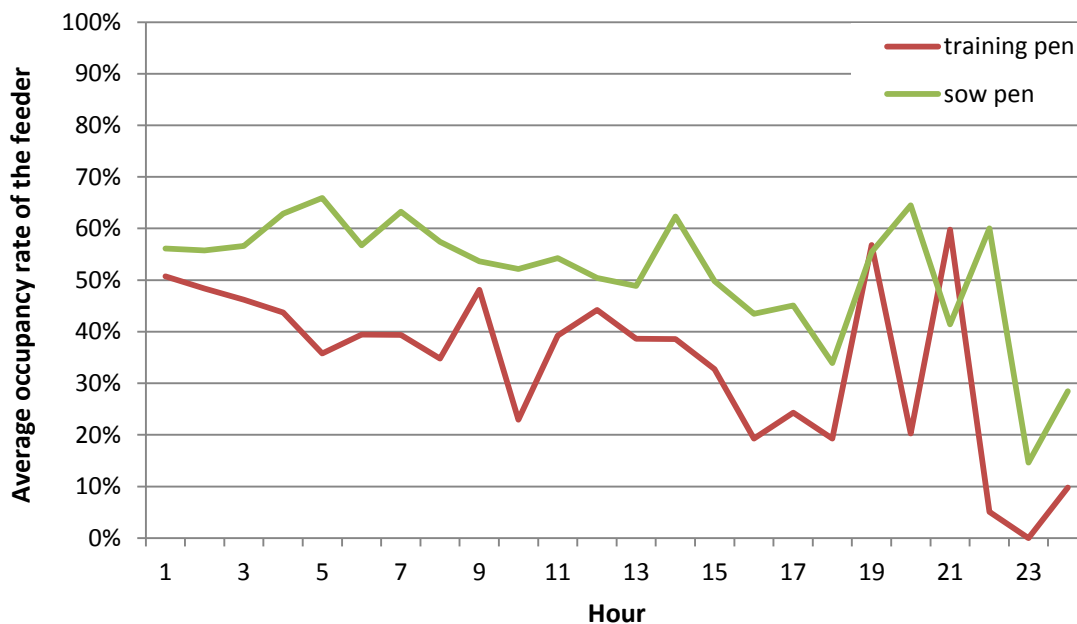


Figure 23 Average occupancy rate of the feeding stations for the tests carried out in the training pen and in the sow pen depending on the time of day

4.3.4 Feeding behaviour of sows in a large group with more than one station

As with the first tests, the number of visits per sow per day varies from one sow to another and from one day to the other. However, a majority of sows will enter the stations only once per day, because the average number of visits per sow per day is 1.12 ± 0.37 (1.13 ± 0.35 visits per sow per day in the training pen and 1.11 ± 0.43 visits per sow per day in the sow pen). It should, however, be noted that the sows in these tests, compared to the first tests, were very familiar with the system, because several of them were fed with this system for more than two months. Also, sows don't seem to have a preference for feeding in one station rather than in another. All of the sows feed in both sow pen stations and the majority of them go almost as much in one than the other.

The order in which sows will feed is similar from one day to another, but never the same, as was the case in the first tests' smaller groups. Once again, the dominant sows usually feed first while the dominated feed later in the day. However, having more than one feeding station in the pens slightly changes that order and allows dominated, but opportunistic, sows to occasionally feed between sows of higher social rank.

As for the number of visits to the stations per day and average occupation time per sow per day, the differences observed between sows seem to be individual rather than linked to social rank. To confirm this, further studies would be required.

4.3.5 Results summary of larger scale tests

The results of the different larger scale tests are summarized in Table 3.

Table 3 Summary of the different results obtained during larger scale tests in the training pen and sow pen

Test	Training pen	Sow pen
Length of stay in stations (min/sow/day)	26.1	32.9
Occupation rate (% of day occupied)	43.9 ± 35.7	55.1 ± 35.7
Number of visit to the stations (visit/sow/day)	1.13 ± 0.35	1.11 ± 0.43

4.3.6 Comments

4.3.6.1 Location of water points

The water points should have been placed in the middle of the pen, in the area with the slat floor, as we recommended. Ferme Aldo's maintenance people installed them on each side of the feeding stations as the installation was easier and closer to the waterline.

It was noted during the tests that the floor around the drinker quickly became dirty since sows tended to defecate there. Thus, the sows used only two water bowls out of the four available in each pen as the others were constantly soiled.

In addition, the location of water points on each side of the stations on the solid floor eliminates potentially interesting places for sows wanting to lie down, as they tend to prefer to lie on a solid floor and lean on solid walls. As can be seen in Figure 24b, some sows pass by the rest area and lie in the activity area behind the feeding stations. This is proof of a lack of resting space for sows.

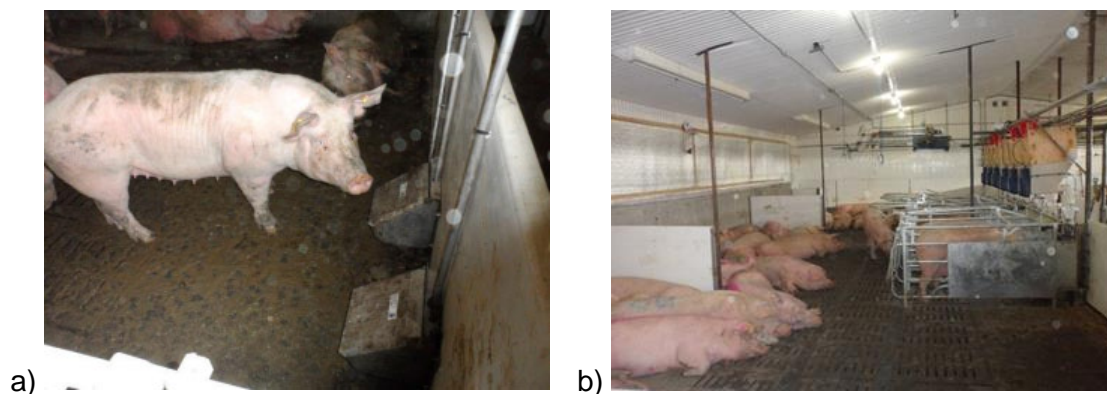


Figure 24 a) Floor dirty under incorrectly positioned drinker, b) sows lying in the activity area behind the feeding stations

4.3.6.2 Positioning of the anti-sleeping bars

The anti-sleeping bars' positioning inside the feeding stations is very important. An anti-sleeping bar installed a bit too forward allows sows to sit in the station and thus be partly protected by the bar (Figure 25).



Figure 25 Sow sitting in a feeding station behind the anti-sleeping bar

To rectify this situation, the bar should be extended so as to be positioned as close as possible to the door.

4.3.6.3 Feeders used in the prototypes

Feeders used in the prototypes were recovered from an old farrowing barn. These feeders are not suitable to use in feeding stations. They are not wide enough and larger sows are not comfortable putting their head in the feeder to eat their ration. Sows prefer to take a mouthful of feed and then take their head out of the feeder to chew and swallow it (Figure 26). This results in sows dropping large quantities of feed on the floor around the feeder.



Figure 26 Feeders not quite wide enough and accumulation of feed around them

This means that sows take more time eating their rations, since once they have finished eating what's in the feeder, they eat the feed that fell on the ground. There is also feed that falls in places that are not accessible to sows. This feed is wasted and may cause problems if it is not removed (fermentation, mold, toxins, ideal condition for the proliferation of flies...).

5 Layout criteria to respect in a Gestal group system

Sow group management has a huge impact on buildings and herd management. It is important to determine the standard (Canadian Code or European standards) and the type of herd management (number of batches, herd renewal rate, static or dynamic group management, manure management type...) that the breeder wishes to abide by prior to starting the work. These elements have huge impacts on the building's layout. Indeed, the chosen standard determines the minimum surface area (sq ft) allotted to each sow as well as the number of sow batches that must be in a group. With respect to herd management, it allows to determine the number of sows per group and also dictates certain criteria to respect for a functional pen layout.

The pen design and layout is extremely important to avoid confusion in the group. As with the ESF system, a pen with this new feeding system must have three distinct areas; a feeding area, an activity area and a rest area.

The feeding area is where feeding stations are located. This area's floor should ideally be slatted, or at least the area at the rear of feed stations.

The activity area, as its name implies, allows easy movement of sows within the pen. This zone should be a minimum of 8 ft wide, ideally 10 ft wide, depending on pen configuration. This area's floor should be fully slatted as this is the area where sows will defecate. In addition, water points must be positioned in this area, not far from the feeding stations.

Finally, the rest area is where sows will lie down. This area must be designed to encourage peace and comfort for sows. Small rest areas, of about 6 to 7 ft deep by about 10 ft long, are recommended over large (10 x 20 ft) rest areas. Smaller rest areas allow sows to move easily within the pen without disturbing other sows. In addition, since sows prefer to lie down along a wall or a pen division, small rest areas meet this preference better than large ones. This area's floor can be made of solid concrete or slats, but sows prefer to lie down on a solid floor.

Also, the ventilation must be designed to avoid draughts on sows during cold season and inversely, to direct air into this area during summer.

Failure to respect these areas or pen misconfiguration leads to confusion within the group with regards to these different areas which means that sows do not respect them and will defecate anywhere in the pen. This is what happened in the small room where the tests with four sow groups took place. The pen quickly became very dirty as sows defecated everywhere. In addition, ventilation in that room was not adequate, which made things worse.

6 Sample plans and estimation of renovation costs

Sample plans for three scenarios are suggested; plans for maternities with 250, 550 and 2,400 sows in production. For each of these scenarios, plans for rearranging the pen and renovation costs are presented as if it were a lower cost renovation or a major renovation of the gestation area. In all cases, the Canadian Code standards were minimally met and buildings were not expanded. In addition, the same number of productive sows was retained.

6.1 Parameters considered in lower cost renovations

In lower cost renovation scenarios, the floors are left and used as is. The only change made to the floor is to block the manure slides in the maternity, using a metal plate and galvanized steel rivets designed for concrete (Figure 16). In addition, the concrete under the drinkers that were removed was redone to obtain a uniform floor. Other parameters taken into account to determine the transformation cost are:

- Labour to remove gestation equipment;
 - Gestation stalls, pen divisions, dispensers, feed containers, automatic feeders and drinkers.
- Labour for installing equipment and pen divisions for group housing;
- Labour for modifications;
 - Modification of water lines;
 - Modification of electricity to install a 120V electrical outlet per feeding station on independent electrical circuits;
 - Redo interior finish of lower part of outlining walls to avoid that sows destroy it.
- Recovery of the automatic feeder transmission;
- Purchase of PVC pen divisions and galvanized steel posts;
- Purchase of a gate with a manway to facilitate working with sows in groups
- Purchase of water bowls (1 bowl for 10 to 15 sows);
- Purchase of the Gestal feeding stations and computer system for its operation (average of approximately 15 sows per station);
 - The cost of the feeding stations is \$ 2,500.

6.2 Parameters considered in major renovations

With major renovations, existing floors are broken to allow for an entirely slatted floor in the centre of the building, except for the solid concrete parts located along the exterior walls, which are kept and will serve as rest areas for sows. The other parameters taken into account to determine the cost of major renovations are:

- Labour:
 - to remove stall gestation equipment;
 - Gestation stalls, pen divisions, dispensers, feed containers, automatic feeders and drinkers.
 - for installing equipment and pen divisions for group housing;
 - Modification of water lines;
 - Modification of electricity to install a 120V electrical outlet per feeding station on independent electrical circuits;
 - Redo interior finish of lower part of outlining walls to avoid that sows destroy it.

- Cost to break up the concrete, redo the concrete and new slats;
- Cost of new scrapers for manure disposal;
- Purchase of a new automatic feeder;
- Purchase of PVC pen divisions and galvanized steel posts;
- Purchase of a gate with a manway to facilitate working with sows in groups;
- Purchase of water bowls (1 bowl for 10 to 15 sows);
- Purchase of the Gestal feeding stations and the computer system for its operation (average of approximately 15 sows per station);
 - The cost of the feeding stations is \$ 2,500.

6.3 Scenarios for the transformation of a 250 productive sow maternity

The 250 sow maternity is managed in farrowing batches every 4 weeks. Each batch consists of 41 multiparous sows and nine gilts for a total of 50 animals. An addition of 18 gilts is done every eight weeks (renewal rate of approx. 45%). The breeding area, with 100 places total, is not renovated and is therefore left as is. Rather, it is the confirmed gestation (132 places) and acclimatization (18 places) sections that are modified.

The transition to sow group housing from a batch farrowing system that farrows batches of sows every 4 weeks means that there are three sow batches that must be housed in groups. The other two batches are kept in the breeding section and farrowing area, respectively.

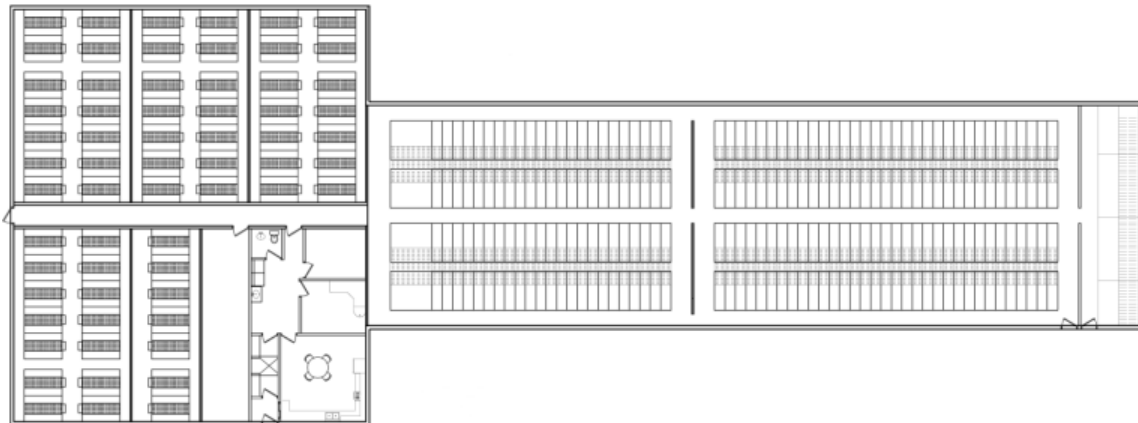


Figure 27 Initial layout of the 250 productive sow maternity in stalls

6.3.1 Lower cost renovation scenario

In this scenario, the group gestation area is composed of four pens (Figure 28).

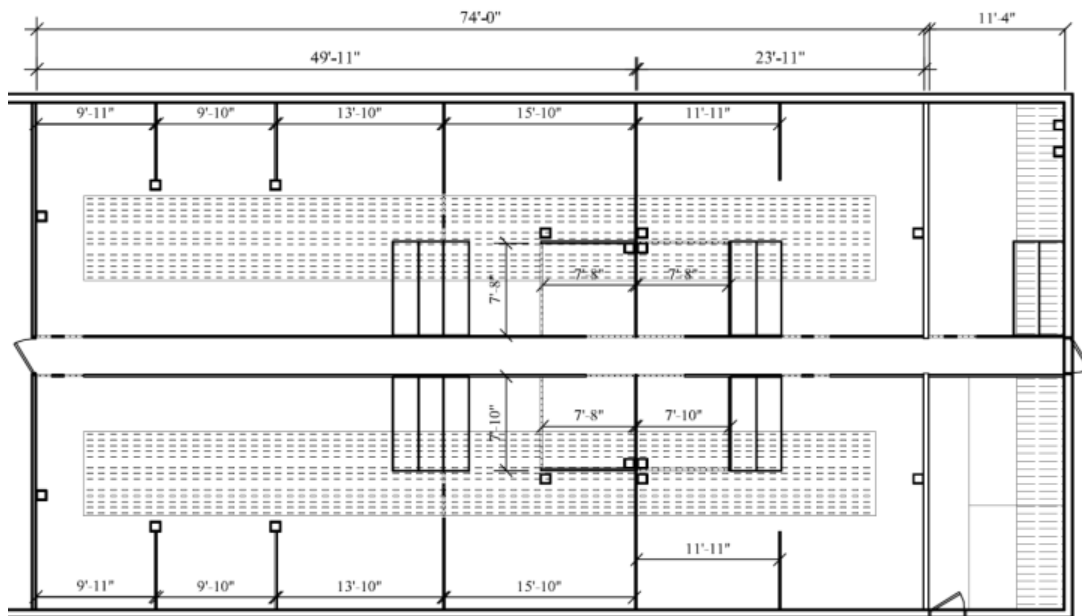


Figure 28 Overall layout plan for lower cost renovation of a 250 sow maternity to group gestation

All the pens have rest areas that are 6 ft 6 in deep and of different lengths along the exterior walls. To establish them as resting areas, they have a solid floor. In addition, several gates with a manway are positioned at strategic locations to facilitate sow observation by the breeder, allowing him to walk through sows without having to manipulate any barriers.

Bigger pens can be divided in two using a perforated removable barrier, thereby allowing for 35 multiparous sows (19 sq. ft/sow) in the larger section of the pen and 15 parity 1 and 2 sows (16.7 to 20.8 square ft/sow depending on the use or non-use of a hospital pen) in the smaller section of the pen (Figure 29). This way, smaller sows suffer less competition when they are housed with older sows.

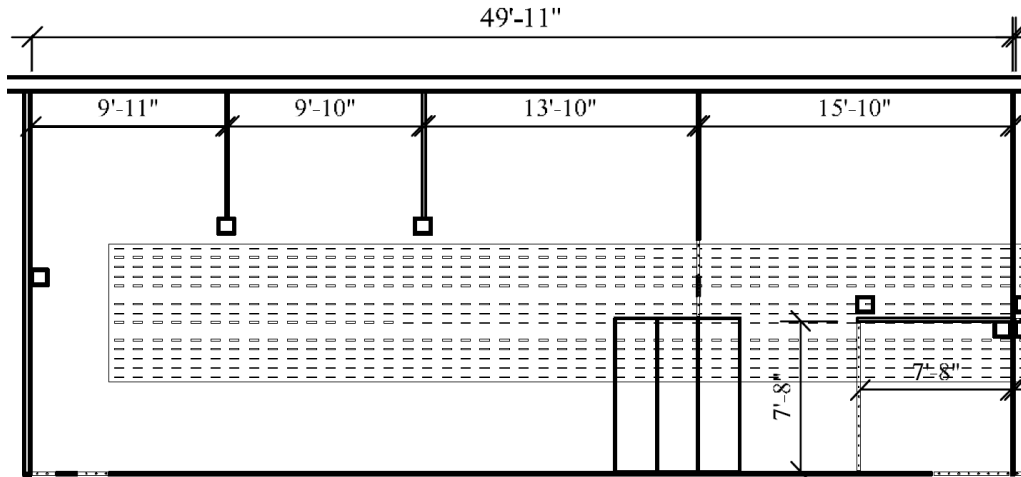


Figure 29 Layout plan for a large pen housing one batch using the scenario for lower cost renovation of a 250 productive sow maternity

Three water bowls are installed above the slats in the larger section of the pen and two in the smaller section. In addition, a removable barrier transforms part of this space into a hospital pen for problematic sows. It is recommended, in ESF systems, to keep between 3 and 5% of the pen reserved for sick or problematic sows. This ratio is respected in this group housing system.

The third group batch is divided into two small pens near the acclimatization section (Figure 30). The first pen can accommodate 26 small sows (18 sq. ft/sow) (parity 1, 2 and 3) and the other, 24 larger sows (19.5 sq ft/sow). Each of these pens has 3 water bowls over the slatted area and a part of their space may be transformed into a hospital pen using moveable perforated barriers.

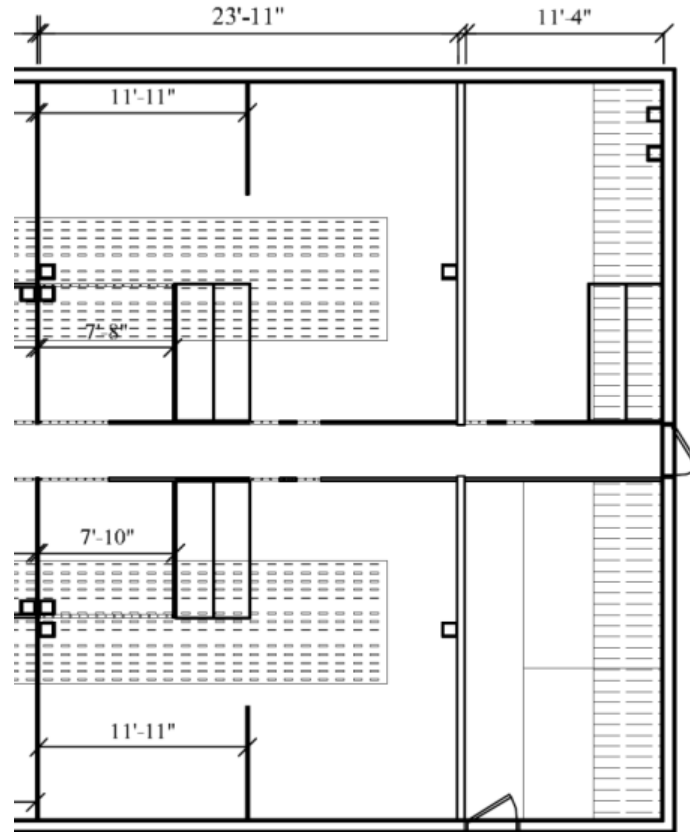


Figure 30 Layout plan for small pens housing the third batch and the acclimatization area using the low cost renovation scenario for a 250 productive sow maternity

Finally, the acclimatization section is partly modified into a training area for gilts. Half of the acclimatization section remains unchanged while the other half is modified. In the modified part, two Gestal feeding stations are installed to be used for training nine gilts. Nine other gilts are housed in pens. After three or four weeks of training, these gilts can be placed in pens, allowing the nine other gilts to learn the system.

6.3.1.1 Cost of a minor renovation of the 250 sow maternity

The total cost of this renovation to house 250 sows in groups was \$94,450, which is \$377 per productive sow (Table 4). The greatest expense is for the purchase of 12 feeding stations (\$30,000) and building materials (wood and concrete) as well as labour (\$22,000 and \$11,000).

Table 4 Break down of costs for a minor renovation of a 250 sow maternity

Description	Cost (\$)*	\$/productive sow*
Lower external wall protection (labour and materials) and installation of equipment and pen divisions for sow group housing	22 000	88
Removal of drinkers and smooth floor installation (materials and labor)	11 000	44
Block manure slide on the slats in gestation area	2 750	11
PVC and metal divisions	7 150	29
Automatic feeder in gestation (materials and installation)	7 150	29
Electricity (material and labor)	5 500	22
Plumbing and water bowls (materials and labor)	8 800	35
Gestal feeding station	30 000	120
Total	94 350	377

*10 % contingency included

6.3.2 Major renovation scenario

The pen layout for the management of the three sow batches is exactly the same as in the lower cost renovation scenario (Figure 31). The only differences are that the concrete was broken-up in the centre of the building (on each side of the central aisle) and that the concrete slats are new.

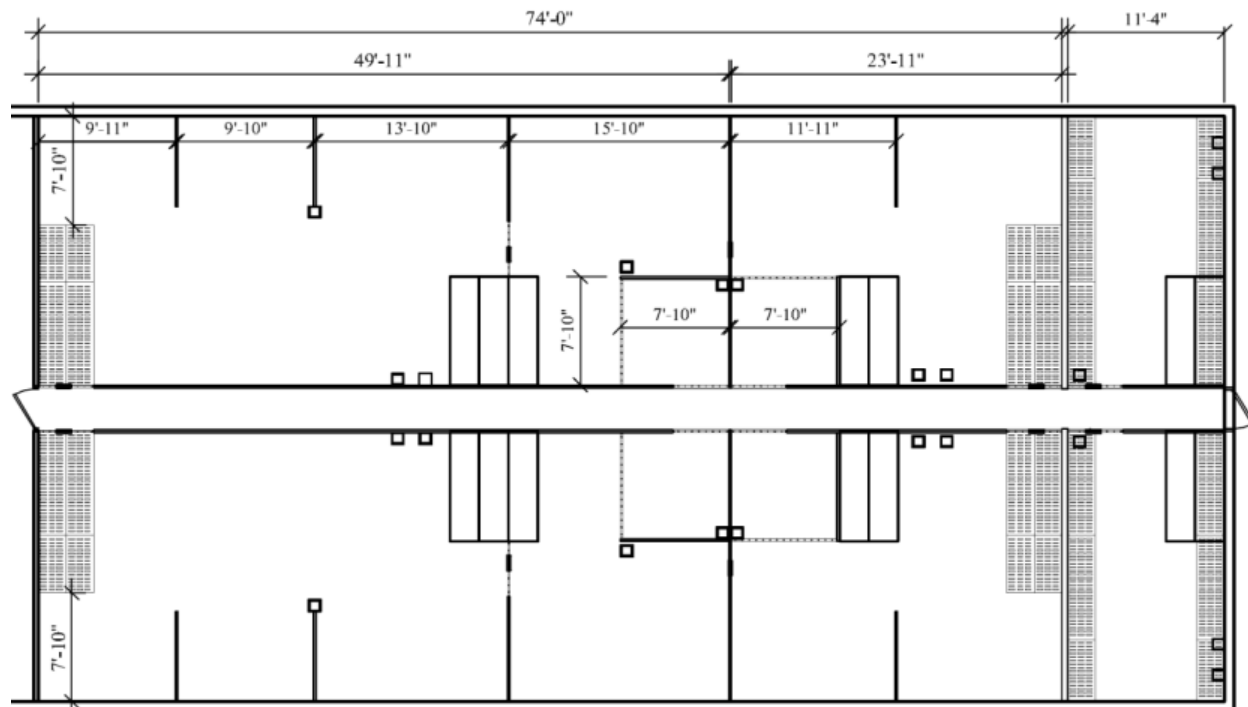


Figure 31 Overall layout plan for a major renovation of a 250 sow maternity to group gestation

The major difference in this layout is the water points' position in the pen. They are now located at the front of the pen near feeding stations so as to concentrate sow activity in that area.

Another difference with this scenario regards gilt training (Figure 32). With this scenario two identical pens of nine gilts, holding two stations each, allow for the training of animals during their acclimatization.

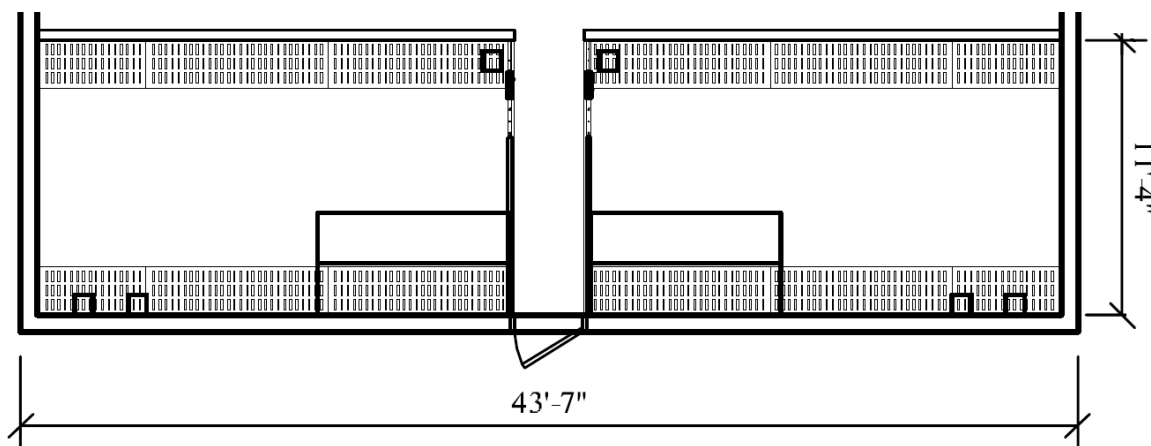


Figure 32 Layout for the acclimatization section in a major renovation scenario for a 250 sow maternity

6.3.2.1 Cost of a major renovation of a 250 sow maternity

The cost of a major renovation is 30% higher than the lower cost renovation. It totals \$135,100, or \$541 per productive sow (Table 3). This cost increase is almost entirely due to changes to the floor and scrapers (\$31,900) and the purchase of two additional Gestal feeding stations for gilt training (\$5,000).

Table 5 Break down of costs for a major renovation of a 250 sow maternity

Description	Cost (\$)*	\$/productive sow*
Materials (protection of bottom of exterior wall) and labor (remove and install equipment)	22 000	88
Breaking concrete, redo the scuppers and new slats (materials and labor)	40 700	163
Manure scrapers	4 950	20
PVC and metal divisions	6 600	26
Automatic feeder in gestation and acclimatization (materials and installation)	9 900	40
Electricity (material and labor)	5 500	22
Plumbing and water bowls (materials and labor)	10 450	42
Gestal feeding station	35 000	140
Total	135 100	541

*10% contingency included

6.4 Scenarios for the transformation of a 550 sow maternity

The gestation and breeding areas of the maternity are 199 ft long by 61 ft wide and have six rows of gestation stalls (Figure 33). The 550 sow maternity is conducted in a batch farrowing system, where sows are farrowed in batches every two weeks. Each batch consists of 46 multiparous sows and nine gilts for a total of 55 animals. To house gestating sows in groups on this farm, six sow batches have to be in groups. To manage this, a space 115 ft long over the entire width of the building is required. This leaves 220 places total which serve as a breeding section and which are renovated.

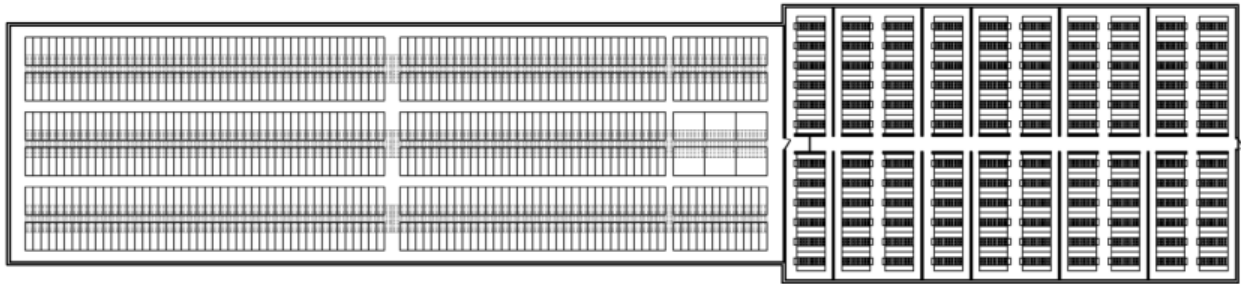


Figure 33 Initial layout for the maternity of 550 productive sows in stalls

6.4.1 Lower cost renovation scenario

The gestation area for gestating sow groups is divided into six large pens that are able to accommodate 46 multiparous sows (19 sq. ft/sow) and six small pens that hold nine gilts (18 sq. ft/gilt) (Figure 34). Each batch of 55 animals requires a large and a small pen. With group management, it is recommended, when possible, to house all gilts in a pen separate from sows. It was done in this scenario.

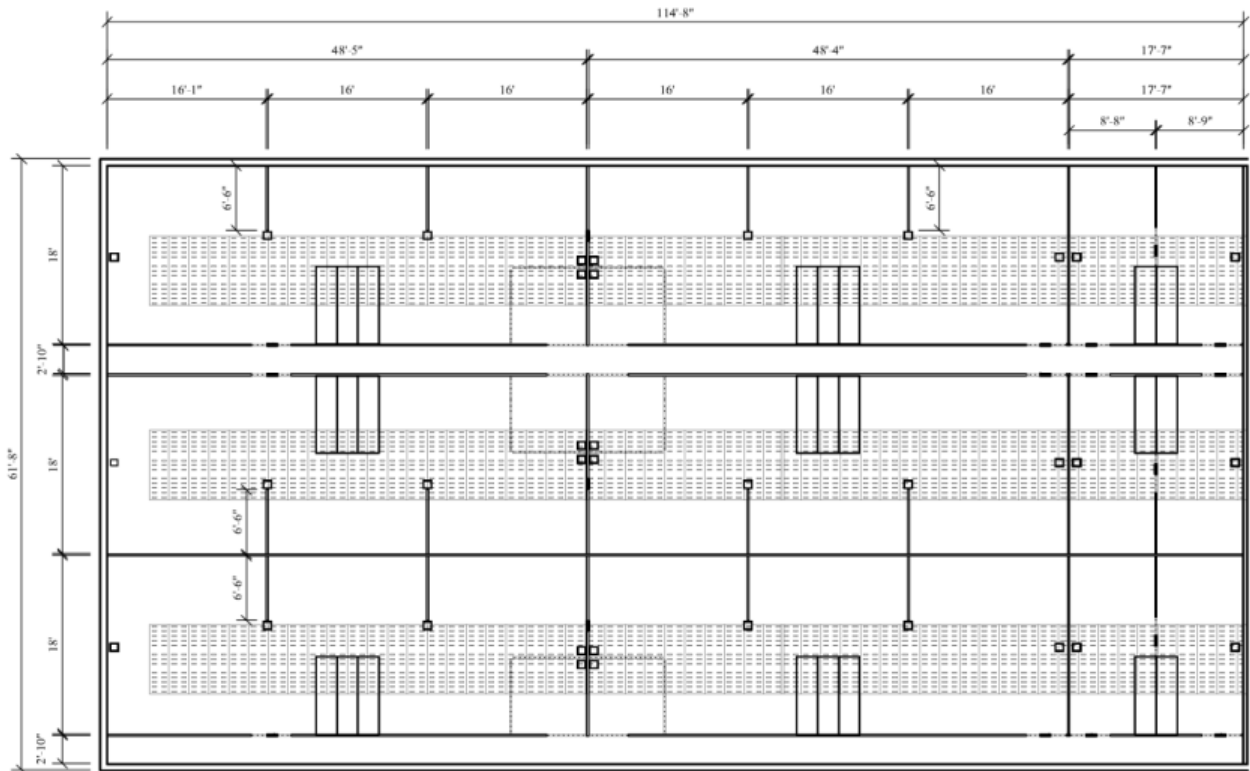


Figure 34 Overall layout plan for a low cost renovation of a 550 sow maternity to group gestation

Each large pen measures 48 ft 5 in long by 18 ft deep (Figure 35). Three feeding stations are positioned in the centre of the pen to feed 46 multiparous sows. The pen's four drinkers are positioned in the slatted activity area. Finally, the rest area consists of three 16 ft wide sleeping areas to avoid having pen divisions near feeding stations, which would hinder sow movement in the pen. Finally, in each pen, a movable barrier allows it to be subdivided to create a hospital pen for problematic sows.

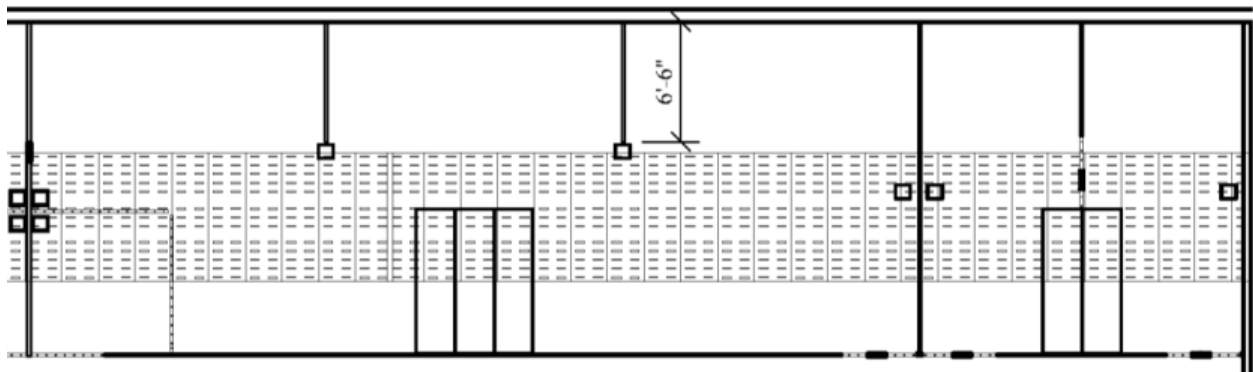


Figure 35 Layout plan for a low cost renovation scenario of a 550 sow maternity to pens for sows and gilts

The six small pens used to accommodate gilts are nine feet wide by 18 ft deep. In each pen, a feeding station and a drinker are available for the gilts. A perforated barrier serving as a gate with a manway is positioned in front of the feeding stations that are side by side and feed two gilt pens.

With this scenario, it is possible to accommodate up to 18 problematic sows in removable hospital pens, which represents 5 % of the sow group and complies with recommendations in this regard.

6.4.1.1 Cost of a minor renovation of a 550 sow maternity

The total cost of transitioning to sow group housing in a 550 sow maternity is \$176,875, or \$322 per productive sow (Table 6). Again, it is the cost of materials (wood and concrete) and labour (\$38,500 and \$22,000) as well as the purchase of 24 Gestal feeding stations (\$60,000) that represent the largest proportion of expenses.

Table 6 Break down of costs for a minor renovation of a 550 sow maternity

Description	Cost (\$)*	\$/productive sow*
Materials (protection of bottom of exterior wall) and labor (remove and install equipment)	38 500	70
Remove the drinkers and the smooth floor (materials and labor)	22 000	40
Block manure slide on the slats in gestation area	4 400	8
PVC and metal divisions	14 300	27
Automatic feeder in gestation (materials and installation)	12 375	22
Electricity (material and labor)	9 900	18
Plumbing and water bowls (materials and labor)	15 400	28
Gestal feeding station	60 000	109
Total	176 875	322

*10% contingency included

6.4.2 Major renovation scenario

In this major renovation scenario, the floor and scuppers are completely redone. The floor is fully slatted, except along two exterior walls where there are 7 ft sections of concrete.

As in the low cost renovation scenario, the gestation area for the sow groups is 115 ft long (Figure 36). There also, gilts are housed in small pens apart from multiparous sows.

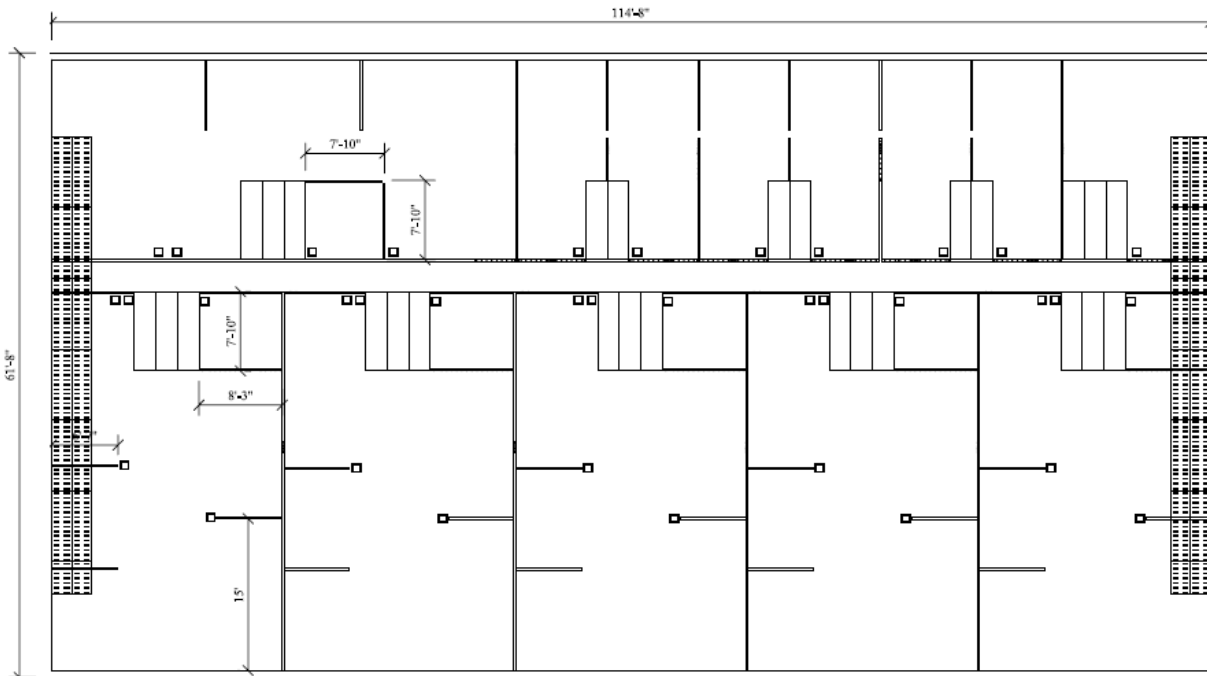


Figure 36 Overall layout of a major renovation of a 550 sow maternity to group gestation

Five big pens (23 ft wide by 37 feet deep) are used to each house a batch of 46 multiparous sows (19 sq. ft/sow) (Figure 37). In each pen, three feeding stations and five water points are used for feeding sows. In addition, the pen can be subdivided, using removable barriers, to form a hospital pen for problematic sows. The rest area is divided by 6 ft 6 in panels, set 10 ft apart on one side and 15 ft on the other. That leaves 10 ft for the circulation between rest areas.

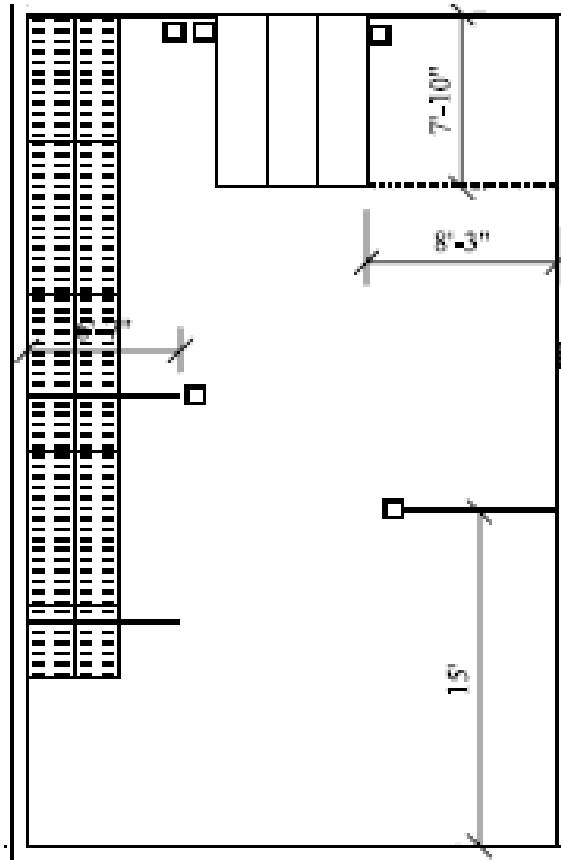


Figure 37 Layout for a major renovation scenario of a 550 sow maternity to sow pens

The sixth multiparous sow pen measures 46 ft long by 19 ft deep. It consists of three sleeping areas, 15 ft 4 in long, and three feeding stations. Four drinkers are installed on the front of the pen, near the feeding stations, in order to concentrate all sow activities in the same area and foster peace in the rest of the pen.

The six gilt pens are very similar to those of the low cost scenario, except that the drinkers are placed at the front of the pen near the feeding stations and that these pens are slightly deeper (19 ft), which increases the surface area per gilt to 19 sq ft (Figure 38).

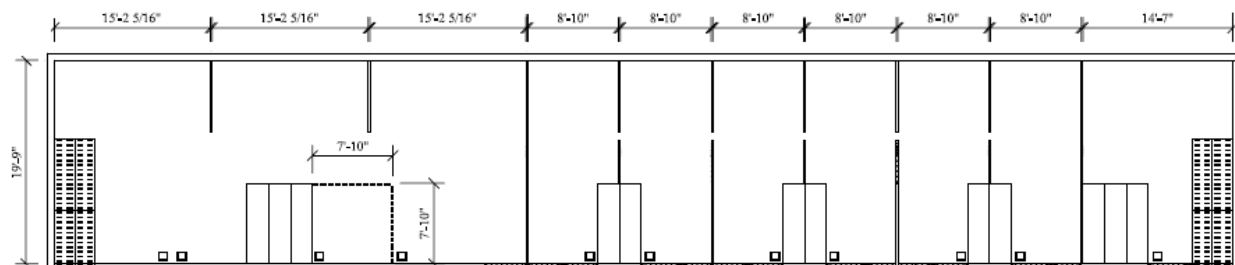


Figure 38 Layout plan for the gilts pen and the training pen

Finally, this scenario affords more usable space to sows as the space used as a passageway has been recovered. This additional space allows us to install a guilt training pen. This pen is 15 ft long by 19 ft deep and can train 18 gilts at a time, using three feeding stations.

6.4.3 Cost of a major renovation of a 550 sow maternity

The cost of a major renovation of a 550 sow maternity is \$252,795, or \$459 per productive sow (Table 7). Changes to the floors account for nearly a third of the cost of the renovation (\$79,750). In this scenario, 27 Gestal stations are required to feed six batches of sow groups and the training pen.

Table 7 Break down of costs for a major renovation of a 550 sow maternity

Description	Cost (\$)*	\$/productive sow*
Materials (protection of bottom of exterior wall) and labor (remove and install equipment)	44 000	80
Breaking concrete, redo the scuppers and new slats (materials and labor)	79 750	145
Manure scrapers	10 450	19
PVC and metal divisions	13 750	25
Automatic feeder in gestation (materials and installation)	12 375	22
Electricity (material and labor)	9 900	18
Plumbing and water bowls (materials and labor)	15 070	27
Gestal feeding station	67 500	123
Total	252 795	459

*10% contingency included

6.5 Scenarios for the transformation of a 2,400 sow maternity

The 2,400 productive sow maternity is conducted as a batch farrowing system where sows are farrowed in batches on a weekly basis. Each of the 20 batches consist of 100 multiparous sows and 20 gilts. The initial gestation area, including a breeding section, is 576 ft long by 84 ft wide and has eight rows of gestation stalls (Figure 39). For sow group housing, the acclimatization and confirmed gestation sections are modified. The section used for breeding is left as is and has 784 places.

The acclimatization section, of 110 places, is 57 ft long by 39 ft deep. The dimensions of the confirmed gestation area that will be used to accommodate sow groups are 368 ft x 84 ft. For housing sow groups farrowed on a weekly basis, 12 batches must be housed in groups.

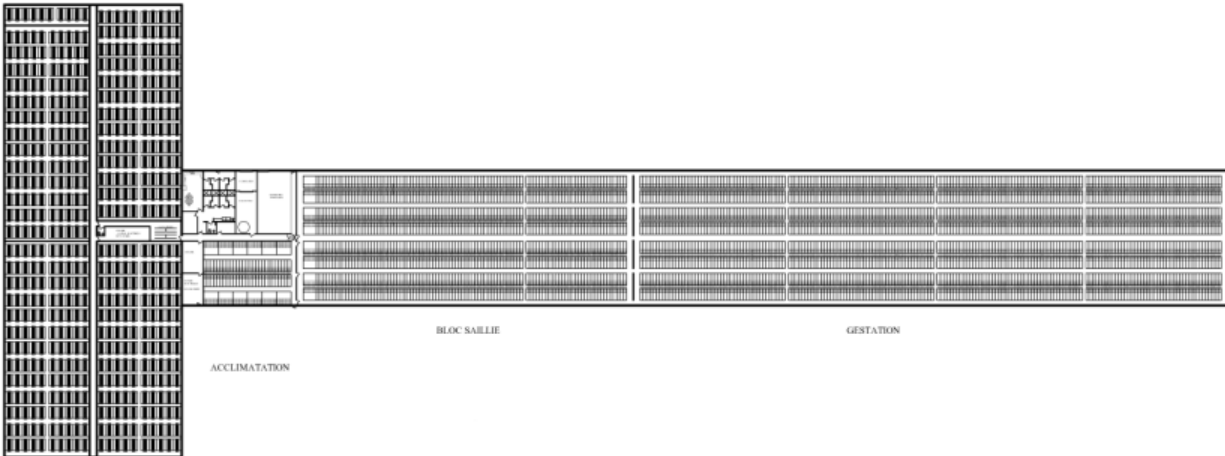


Figure 39 Initial layout plan for the 2,400 sow maternity in stalls

6.5.1 Lower cost renovation scenario

6.5.1.1 Acclimatization

The acclimatization area is rearranged to train gilts in using this new feeding system. The only acclimatization area that is not changed is the one with 6 pens and is near the office. These pens can be used to accommodate boars or problematic gilts.

Three training pens (16 ft 8 in x 17 ft) were built where the gestation stalls used to be (Figure 40). In each of these pens, three feeding stations are installed to feed and train a maximum of 19 gilts (15 sq ft/gilt).

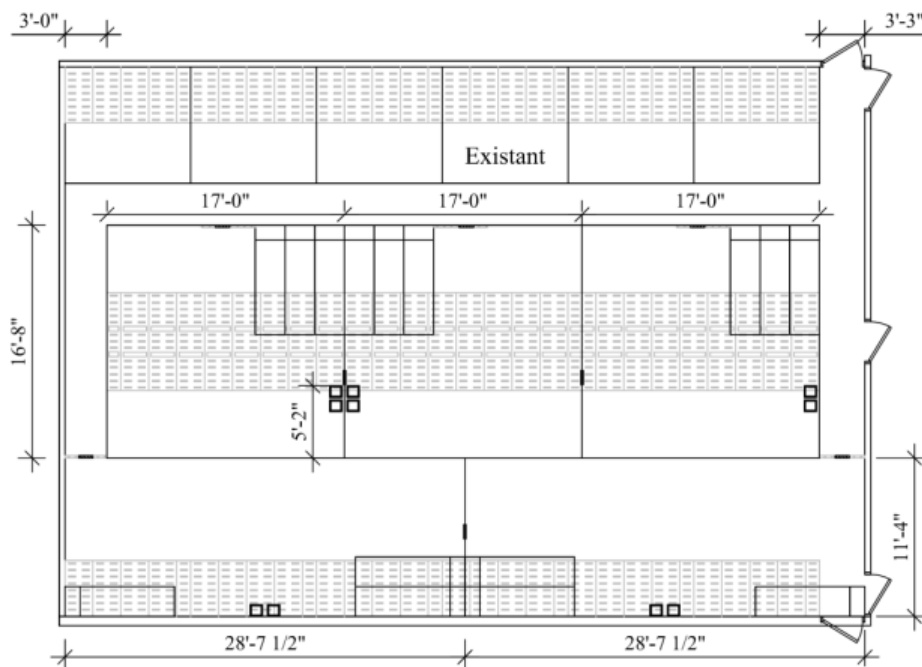


Figure 40 Layout plan for the acclimatization area using the low cost renovation scenario for a 2,400 productive sow maternity.

In addition, two other pens (11 ft 4 in x 28 ft 7.5 in) are also arranged for training a maximum of 19 gilts. Since the back of the stations must be installed on the slatted section of the pen, three stations in each of these pens could not be installed side by side since the existing floor has only 4 ft of slats. Instead, they were installed as shown in Figure 41.

Each of the five training pens have two drinkers which are placed above the slatted floor section and behind the entrance to the stations, this aims to concentrate gilt activity around the stations and promote peace in the rest of the pen.

6.5.1.2 Group gestation section

The group gestation area is made up of 12 pens which are identical except for their depth. The pens located along the exterior walls are 19 ft 8 in deep (20.6 sq ft/sow and 17.8 sq ft/gilt), while those located in the centre of the building are 18 ft 9 in deep (19.6 sq ft/sow and 16.9 sq ft/gilt) (Figure 41).

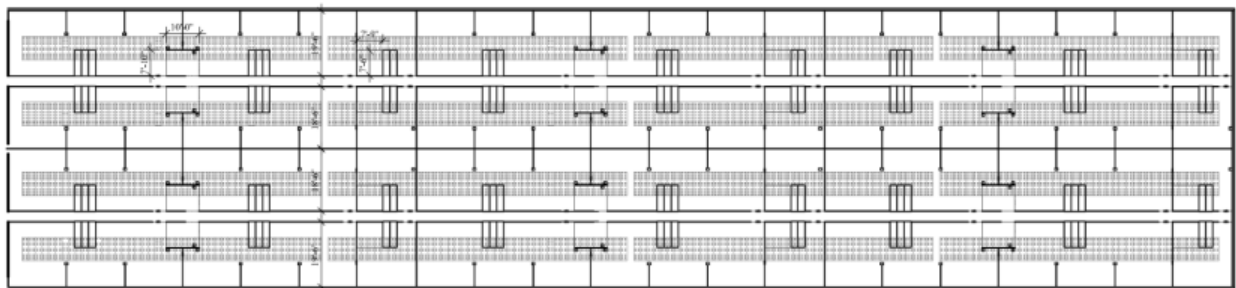


Figure 41 Overall layout plan for a low cost renovation of a 2,400 sow maternity to group gestation

All of these pens are identical. Each pen is divided into three sections, two large areas are able to house 50 sows each and a smaller area houses 20 gilts (Figure 42)

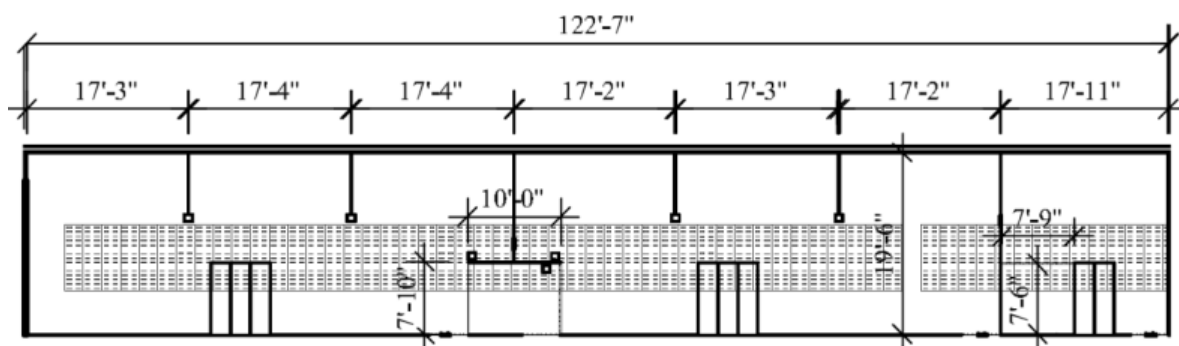


Figure 42 Layout plan for a pen housing a batch using the lower cost renovation scenario for a 2,400 productive sow maternity

Each of the larger areas has three feeding stations and three drinkers placed over the slatted floor. Also, a hospital pen is located between the two larger pens and can house up to four sows. The rest area is divided into rest areas varying in size from 17 ft 2 in to 17 ft 4 in by 6 ft 6 in deep.

The small gilt pen is 18 ft wide and has two feeding stations and two drinkers. In addition, the pen can be subdivided using removable barriers to form a hospital pen.

6.5.1.3 The cost of the low cost renovation of a 2,400 sow maternity

For the low cost transition to group housing with the Gestal system, it takes \$668,200 (\$278/productive sow) to carry out the work (Table 8). In total, 108 feeding stations are required for the herd (\$270,000).

Table 8 Break down of costs for a minor renovation of a 2,400 sow maternity

Description	Cost (\$)*	\$/productive sow*
Materials (protection of bottom of exterior wall) and labor (remove and install equipment)	121 000	50
Remove the drinkers and the smooth floor (materials and labor)	44 000	19
Block manure slide on the slats in gestation area	13 200	5
PVC and metal divisions	66 000	27
Automatic feeder in gestation and acclimatization (materials and installation)	46 200	20
Electricity (material and labor)	33 000	14
Plumbing and water bowls (materials and labor)	74 800	31
Gestal feeding station	270 000	112
Total	668 200	278

*10% contingency included

6.5.2 Major renovation scenario

6.5.2.1 Acclimatization

The acclimatization area needs to be completely renovated to install a fully slatted floor. Four training pens, nearly 23 ft wide by 18 ft deep, each contain four feeding stations (Figure 43). These each allow the training of 25 gilts (16.4 sq ft/gilt).

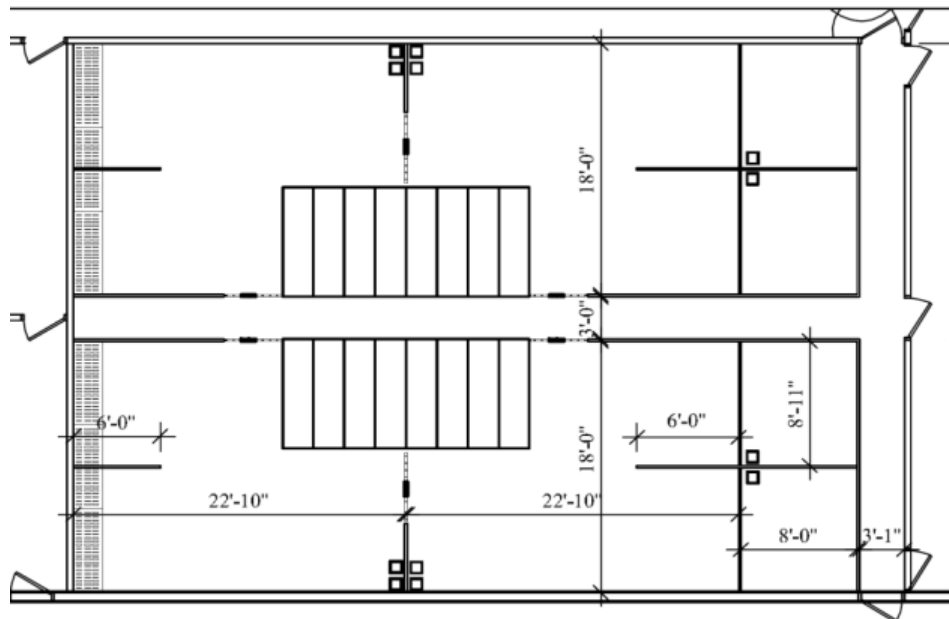


Figure 43 Acclimatization section layout in a major renovation scenario of a 2,400 sow maternity

The drinkers in each training pen are placed on the wall behind the station entrances, in order to concentrate gilt activity around the stations and promote peace in the rest of the pen.

Also, there are four pens that can be used for both boars and problematic gilts.

6.5.2.2 Group gestation section

Gestation in a group in the major renovation scenario of a 2,400 sow maternity is made up of 12 identical pens (Figure 44). The floor is entirely slatted, except for sections of about 7 ft wide, along the exterior walls that are kept full.

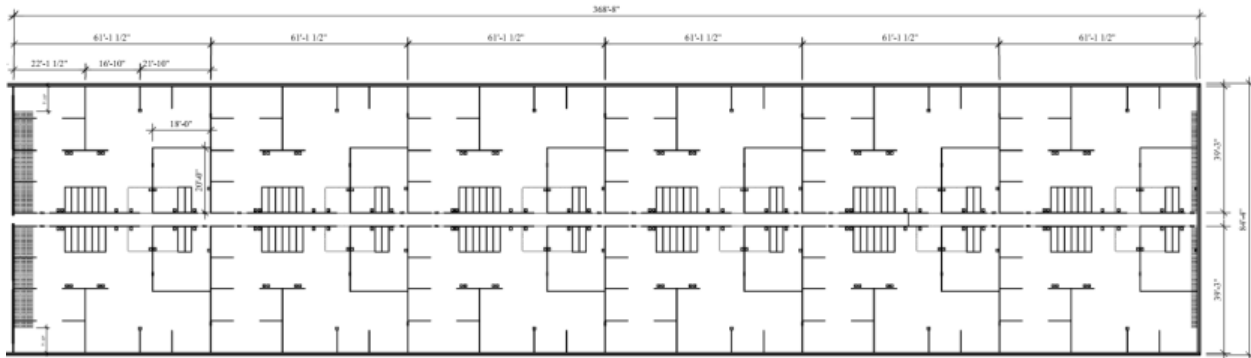


Figure 44 Overall layout plan for a major renovation of a 2,400 sow maternity to group gestation

These pens (61 ft wide by 39 ft deep) are divided in two to accommodate 100 sows and 20 gilts separately (Figure 45). The large section of the pen, used for housing multiparous sows, contains six feeding stations and nine drinkers. The majority of drinkers are near Gestal systems to concentrate activities around them and thereby promote peace in the rest of the pen.

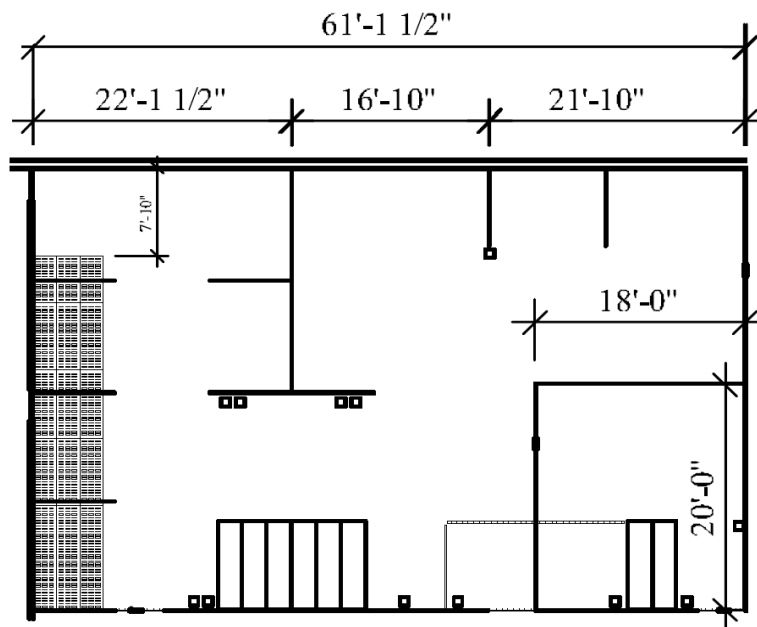


Figure 45 Layout plan for a pen housing one sow batch using the scenario for the major renovation of a 2,400 productive sow maternity

The small gilt pen is 18 ft wide by 20 ft deep and has two feeding stations and two water points. Removable barriers can be deployed both in this pen and in the multiparous sow pen to obtain pens for problematic sows.

6.5.2.3 Cost of a major renovation of a 2,400 sow maternity

The cost of renovations for this maternity to sow group housing with this feeding system is \$970,800, or \$405 per productive sow (Table 9). Costs for the floors account once again for one-third of the renovation costs (\$325,600 and \$30,800).

Table 9 Break down of costs for a major renovation of a 2,400 sow maternity

Description	Cost (\$)*	\$/productive sow*
Materials (protection of bottom of exterior wall) and labor (remove and install equipment)	121 000	51
Breaking concrete, redo the scuppers and new slats (materials and labor)	325 600	135
Manure scrapers	30 800	13
PVC and metal divisions	66 000	28
Automatic feeder in gestation (materials and installation)	46 200	20
Electricity (material and labor)	33 000	14
Plumbing and water bowls (materials and labor)	68 200	28
Gestal feeding station	280 000	116
Total	970 800	405

*10% contingency included

7 Possibilities of a pre-commercial prototype

Pre-commercial prototypes should be available in June 2014. They will have many more possibilities than the previous prototypes as they will be equipped with the Gestal Solo computer platform rather than Gestal XM like the first prototypes. This will allow stations to be truly self-sufficient and no longer dependent on a computer. The computer will serve only to centralize the data sent by the stations. Of course, it is the desktop computer that will produce reports and from which all parameters can be adjusted. However, the decision to feed a sow or not will be taken by the station itself since it can keep the feeding data of the entire herd in its memory. Also, these prototypes will work with wireless technology similar to WiFi, which will greatly facilitate their installation at the farm, and will use the Jyga Technologies antennas.

Two different prototype versions will be offered; one that can distribute a single feed and a second that can distribute two different feeds (available at the end 2014). For each of these prototypes, several feed curves will be proposed. In the version with a single feed, nine different curves will be incorporated into the software; three for gilts, three for parity 2 and 3 sows, and three for the parity 4 and higher sows (Appendix 1). For each sow category, the feed quantities distributed during gestation vary depending on the body condition of sows in this group (lean, healthy or fat) and their gestation stage. For each sow, the farmer will have only to enter the body condition and the rest will be done automatically. The farmer may also customize the feeding curves and create up to 1,000 different curves.

Jyga Technologies is currently working on an even more accurate method to determine the optimum sow feeding curve based on biological parameters such as age, parity, its weight and its body condition at very specific stages. This option of the Gestal system, which targets elite producers, should be available by 2015.

Pre-commercial stations will be equipped with the new feeder which is much more ergonomic (Figure 46). The feeder, which is the same width as the station, will decrease wastage as the feed will no longer fall into places inaccessible by sows.

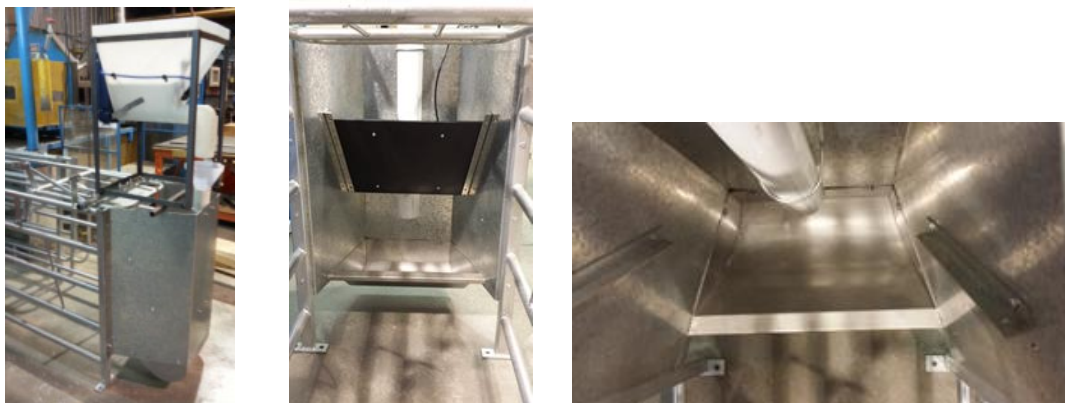


Figure 46 New feeder of the pre-commercial Gestal feeding station

In addition, the feed reserve and the Gestal solo will be removable (Figure 47). To remove these sections of the station, all that is required is to lift the reserve from its base and disconnect the Gestal. This is extremely useful when a station is damaged. Instead of calling the maintenance people to repair a faulty station, the feeding system can be sent to the manufacturer to be fixed. This approach increases farm biosecurity and also allows the farmer to have a functional station

within a few minutes if he keeps a spare feeding system on hand. Stations in the training pens could also be used to replace a faulty station.



Figure 47 Feed reserve and Gestal system that can easily be removed from the base of the feeding station

Stations are equipped with a sensor in the feed reserve, which stops the distribution of feed at the station when the reserve is empty. This prevents the system from serving empty meals, meaning that because it turned on the distribution motors, the systems believes the sow was fed, but since there was no feed in the reserve, the sow received nothing.

This new feeding system for sows housed in groups will make life easier for breeders who use it. When a sow feeds for the first time in a station, the system will automatically “create” its individual record, in other words, the chip number will be registered in the sow’s individual file. Moreover, if the breeder also uses the Gestal system for lactating sows, the system can determine the feeding strategy related to its parity, because it will already have the information on the sow’s status.

As with an ESF system, the breeder can use a portable electronic tag reader that enables him to find a sow in the pen and also to change this sow’s individual settings directly in the pen (for example: the sow’s body condition). In addition, the breeder will also be able to remotely monitor the feeding of his herd via his computer or his smart phone and could even change settings.

The pre-commercial prototype will allow feed distribution to be adjusted at any time between two doses as well as the amount of feed of each dose of more than 50 grams, something which cannot be done in ESF systems where the quantity of feed per dose is connected to a predetermined volume.

Another option to facilitate the breeder’s work is the ability to mark sows that he has determined in advance with a colour spray system. This will allow, for example, to mark the sows that need to be vaccinated, that are due for an ultrasound or to simply determine which sows have passed into the station. This option will be available towards the end of 2014.

As for the compatibility of data recorded by the Gestal system with data analysis software such as PigCHAMP, Winporc, SigaPorc and PigKnows, the Gestal system data is exportable in data spreadsheets. It is therefore compatible with software that can receive this kind of data.

8 Discussion

8.1 Advantages of the group Gestal system compared to ESF, free access stalls and short stalls

The new feeding system developed in this project consists of a hybrid between the ESF system and the free access stalls system. The Gestal feeding stations combine the advantages of each one of these systems: on one side, sow individual feeding within the group just like in the ESF system, and on the other, the simplicity and mechanical ruggedness of the free access stalls.

Compared to the ESF systems, the Gestal system is simpler and cheaper. The cost per sow will depend on the number of sows being fed by the feeding station. Priced at \$2,500 per unit (less if many stations are bought), the cost per sow amounts to \$125 to \$166, depending on the number of sows being fed at every station (15 or 20 sows per station). In comparison, the cost per sow for the ESF systems is of \$150 to \$250¹, depending on the supplier and other options chosen by the breeder.

In the Gestal system, the ratio sow/feeding station (15 to 20) is much lower than the ESF systems' ratio (60 to 80 sows depending on the supplier). This is an advantage as sows have easier access to the feeders. This should mean less social competition between sows for access to feed, which translates into less "dropping out" and less aggressive interactions. Besides, the small sow/station ratio allows more time per sow to consume their daily feed ration.

The small number of sows per station allows for more than one station within the pen for medium groups (20 to 39 sows) to large groups (over 40 sows). This can be particularly beneficial in the case where a feeding station breaks down: other stations will be available to feed the sow group. In the ESF system, pens with only one feeding station are common, which renders sow feeding complicated or even impossible in the case of a breakdown or maintenance operation.

Compared to the free access stalls system, the Gestal system has other advantages: it is cheaper (one stall for 15 to 20 sows instead of one per sow), it requires less space per sow given that 100 % of the space may be used, and it permits individual sow feeding during gestation.

Currently, the only system available that permits individual sow feeding within a sow group is the ESF system. Individual feeding and follow-up on feed consumption are very important during gestation, since it ensures that all sows receive the adequate feed quantity according to their size, body condition and gestation stage. Individual feeding may also lead to less wastage, which translates into a decrease in feeding costs. It also translates into a better homogeneity of sow body condition within a group by distributing adequate feed quantity according to each sow's needs. This is very important as sows are usually rationed during gestation, which means they do not eat their fill.

When feed distribution is not adequately controlled for each sow, like in the short stalls or floor feeding systems, then the competition for feed increases. This renders the feed consumption unequal amongst sows, the dominant ones being the ones who consume more. Aggressiveness and stress then increases within the group and may affect sow productivity.

As opposed to the short stalls, the Gestal system permits individual control of feeding. In addition, the Gestal feeding system's station protects the sow during its meal, which renders feed theft impossible. This system also makes it possible to constitute groups of different sizes

¹ Data collected in 2012 from equipment suppliers

and to adequately control the sow's body condition within each group, which is not the case with the short stalls system. With the short stall system, the maximum recommended group size is of 20 sows. It has been well demonstrated that the bigger the groups, the lesser the aggressiveness between sows when the group is formed.

8.2 System that facilitates transition towards group housing

This new system is easy to install in existing gestation sections with stalls and in new constructions. The fact that it uses Wi-Fi technology dramatically facilitates its installation since there are no wires to set up.

Its installation can easily be carried out without having to make major modifications to the building. The work sequence shown in section 4.1, consisting of removing all equipment and installing the new one is quite easy in comparison to having to break up everything like you would have to do with ESF and free access stall systems, or reinstalling an equipment for each sow in the short stall system.

This system may be adapted to any farm size thanks to its small sow/station ratio (15 to 20 sows/feeding station). It gives small-sized maternities the opportunity of having access to a system where individual sow feeding is possible, which for these breeders was financially and technically very difficult with an ESF system that had a ratio of 60 or 80 sows per station.

For example, even a breeder with 100 sows farrowed in batches every 4 weeks could use this system. This breeder could even choose to use two stations for the 20 sows that constitute each one of his batches (ratio of 10 sows/station) and arrive at the same cost as an ESF system. This breeder would have the advantage of having static sow groups and being able to manage all of his smaller sows in a same pen (parity 1,2 and 3), something that could not be done with the ESF system given that all gestating sows would be housed in a group in the same pen (only one dynamic group). Additionally, the guilt learning process in an ESF system, where there is only one station, represents a big challenge.

For large-sized operations, this system allows the breeder to have many feeding stations in the same pen, which facilitates sows' access to food and diminishes stress and aggressions between sows around feeding stations. For example, for a 60 sow-group, the breeder may choose to have three or four stations to feed them with the Gestal system. With an ESF system, this same group has to be fed with only one station. The probability of having a free station is therefore much higher with the Gestal system than with the ESF one.

The Gestal system for sow groups is very accessible thanks to its low cost per sow and also to its low transition cost from keeping sows in stalls to group management. Its acquisition cost is 11% to 60% lower than the ESF system's and varies according to the sow/Gestal station ratio and to the ESF system manufacturer and options chosen for it.

Regarding the buildings' renovation cost, it is much lower than the costs presented in a study carried out by the CDPQ in 2012 (Table 10). However, be cautious that the costs of major renovations presented in this study were adapted to show those of the breeding and group gestation sections only. Furthermore, these modifications were made in order to comply with European standards instead of with the Canadian code. We can easily notice that the cost of the major renovations required to install the Gestal feeding system is still the lowest.

Table 10 Comparing costs, per productive sow, of equipment and major renovations according to herd size and group housing system

	600 sows	250 sows	Equipment only ³
ESF ¹	579	843	150-250
Short Stall ¹	560	895	90-105
Free Access Stall ¹	857	NA	180-200
Gestal station ²	459	541	125-166
Gestal station ² (low cost)	322	377	

¹ European standards

² Canadian code

³ Data collected in 2012 from equipment suppliers

A last interesting point about this system is that it gives the opportunity to use 100 % of the building's size for rearing, which lets the breeder keep the same amount of sows in his building while still complying with the Canadian code.

8.3 System that facilitates animal training

In order to train sows, a training pen has been set up with six feeding stations providing a small sow/station ratio. This is necessary for providing sows with various possibilities of access to the stations during the learning phase. The cull sows used during the first tryouts successfully learned to access the feeder without help from farm staff. Out of about a hundred sows that passed through this section, only one needed human intervention during the learning phase. Other data and observations must be collected in order to determine the success rate and percentage of sows and gilts that may encounter difficulties in learning how the system works and also to develop the best possible training strategy. Tryouts were conducted with a maximum of 6.7 sows/station ratio, though this ratio could be higher (10 sows or more/station). However, it is clear that the training pen must contain a minimum of two stations. Although, if there are more stations, the learning will be even easier. Overall, it is clear that the training pen is necessary to help sows familiarize with this feeding system, but thanks to the Gestal system's simplicity, the learning process should be much simpler than with the ESF system. Ideally, like with the ESF system, the training should be done on gilts before breeding in order to reduce the negative impact, rendered by missed meals and stress stemming from group trainings, on sow performance.

8.4 Additional studies to be performed

Additional studies would be necessary to demonstrate how the Gestal feeding stations work and how efficient they are in different situations.

- Since different tryouts have been performed on cull sows, it should be demonstrated that this system works well for gestating sows (gilts and gestating multiparous).
- A comparative study of sows' performance within a herd using the Gestal system for grouped sows versus sows kept in stalls.

- A study on gilts' behaviour and performance in this feeding system should be carried out. Gilts have an inferior social status to sows in a group, which in the ESF system usually translates into limited access to feeding stations and having the less interesting places in the pen for resting. It would be important to determine if gilts using the Gestal feeding system need special care like in the ESF system (training, gilt group housing only), or if the easier access to the stations would permit housing them with the multiparous sows.
- A study on the layout of optimal pens (new and renovations) and on the optimal floor type behind and inside the feeding stations. Various reference layout plans are proposed in this report, and they all comply with theoretical layout criteria. It would be a good thing to carry out on-farm trials to confirm this. As for the floors, even if the slatted floor in the tryout pen seemed to work well, other types of flooring should be examined in order to determine what the optimal flooring for new constructions is. This information will also be important for the present building's renovations.
- Data should be collected regarding the average number of visits per sow per day and regarding the total occupation time of stations per sow per day in the stations using the new feeders.
- Additional studies regarding the feeding behaviour of gestating sows (gilts and multiparous) fed with Gestal stations would be necessary and would permit to determine the maximal gestating sow/station ratio. Different sow/feeding station ratios should also be tested. This would help determine the average feeding time per gestating sow per day and also the feeding time of all sows in the group within the daily cycle, information that we do not have at the moment.
- Trials of different pre-training and training strategies on gilts and multiparous sows as well as evaluating the efficiency of these strategies.
- Sow training strategy using a long short stall and an anti-sleeping bar.

9 Conclusion

Gestal, the innovative feeding system for gestation sow groups, offers many advantages compared to other existing systems (ESF, free access stalls and short stalls). Not only in terms of sow management, but in animal well-being as well as system cost. This system allows cheap individual feeding for sow in groups, diminishes competition for access to feed and facilitates training compared to ESF systems.

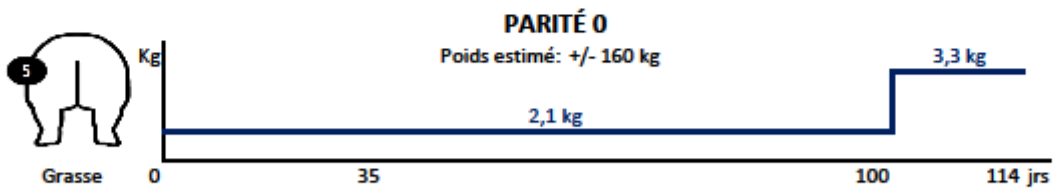
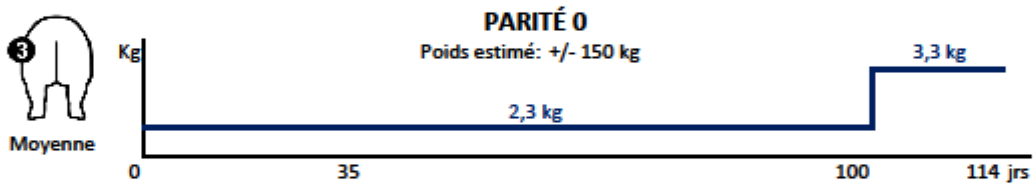
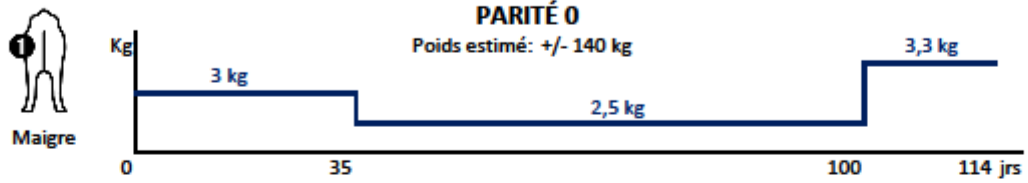
Compared to the free access stalls system, the Gestal system provides cheaper individual feeding and requires less space for sow keeping given that 100 % of the pen space is available to the sow.

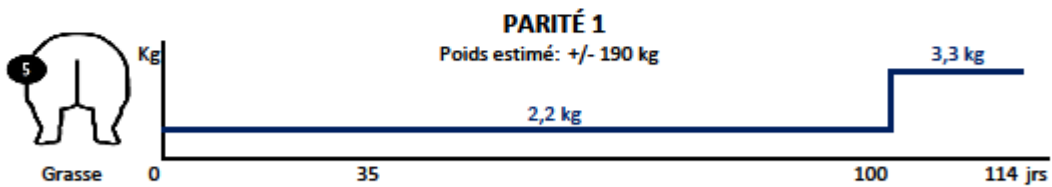
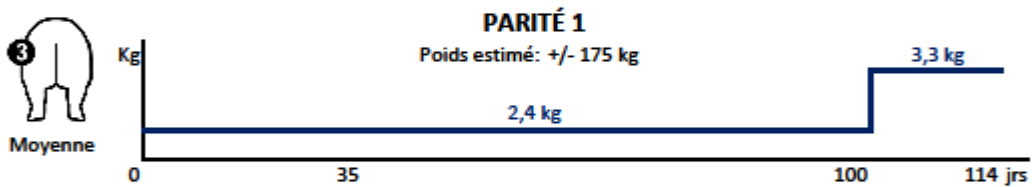
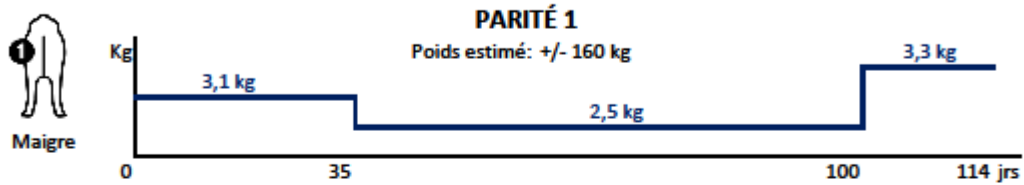
Even though the feeding system and the software enabling it are still under development, observations made on cull sows fed by its different prototypes indicate that with minimal required training, they easily understand how this system works. Observations of the sows' behaviour within the system have shown that aggressions and competition for access to the feeding stations are minimal. Although additional work will be necessary to determine the optimal ratio of sow/feeding station, the present project allows us to state that 20 sows may easily be fed using this feeding system. Globally, this new feeding system, Gestal, shows great potential and will constitute a very interesting alternative for breeders who would like to make the transition to sow group housing and who would also like to be able to offer individual sow feeding, all this at a lower cost compared to other systems.

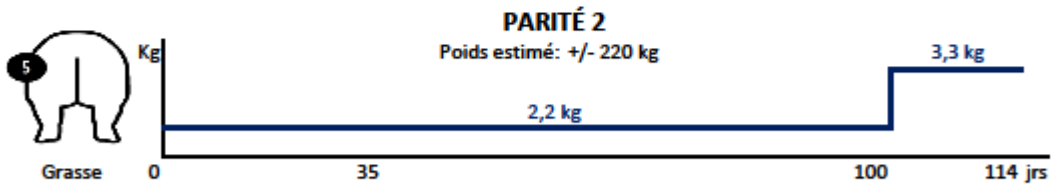
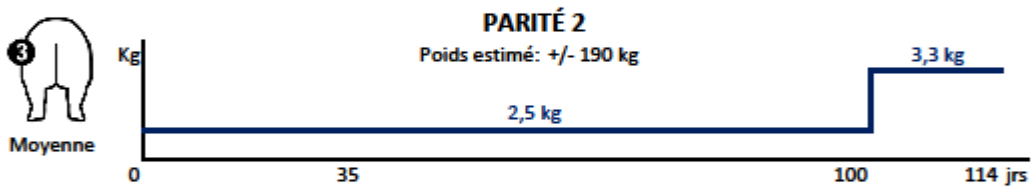
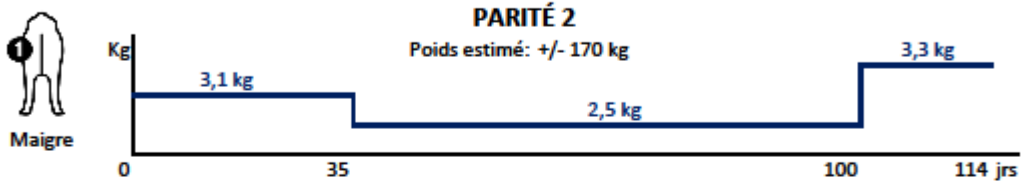
10 References

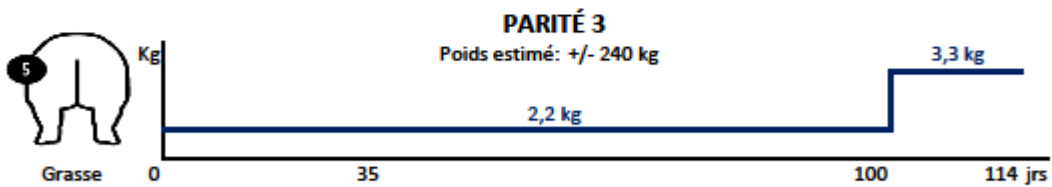
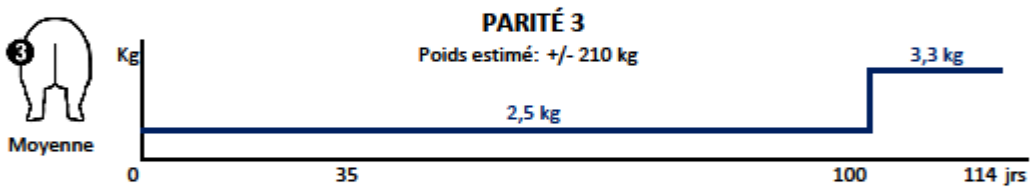
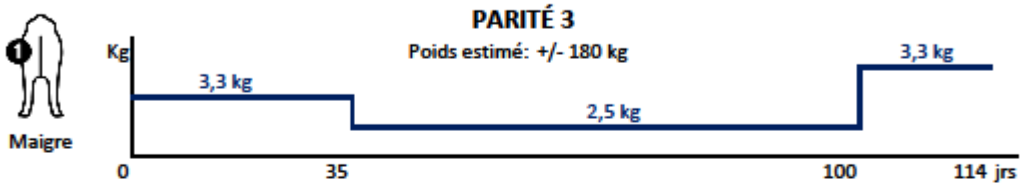
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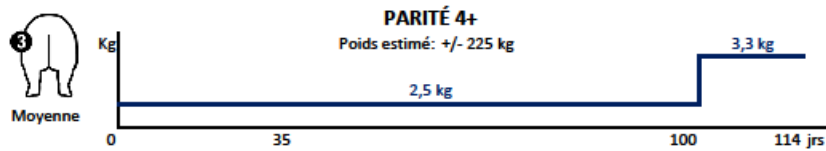
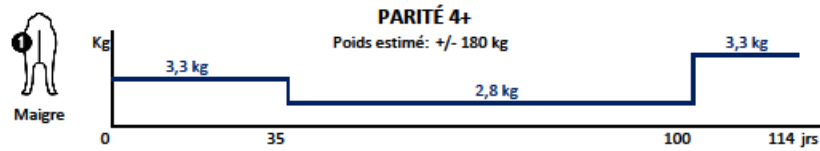
Appendix 1













Centre de développement du porc du Québec inc.
Place de la Cité, tour Belle Cour
2590, boulevard Laurier, bureau 450
Québec (Québec) G1V 4M6

 418 650-2440 •  418 650-1626

cdpq@cdpq.ca • www.cdpq.ca

 @cdpqinc