Farm management
Barn design for robotic milking

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Introduction

Over the years, robotic milking has grown to become a household word. Lely has been involved with robotic milking and robotic dairy farm management since 1992 and has gained extensive experience during this time. A barn geared towards robotic milking and daily management facilitates the comfort of both farmer and cows. New construction offers the possibility of adapting the barn entirely according to the needs of the farmer and his livestock, while conversion calls for a compromise between what is desired and what the existing possibilities have to offer.

This brochure highlights some important aspects of barn construction in relation to the Astronaut milking robot. The following aspects are explained: the different types of barns, floors, cubicles and the ventilation possibilities. In addition, the presence of sufficient light, air and clean water in the barn, as well as the various types of feed fences, will be addressed. Lely Industries operates in a global market, therefore, due to the different legislation and climates around the world, not all information will be applicable to local circumstances.
# Inhoudsopgave

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1 Robotic milking – freedom for farmer and cow

In recent years, the popularity of robotic milking has increased significantly. The motivation of dairy farmers to switch to robotic milking is extremely diverse and it also varies from company to company. The final decision on purchasing a robot depends on the goals of the individual. How will the dairy farmer develop his business in the coming 5 to 10 years? In family run businesses personal preferences will play a role, such as the alleviation of physical labour and more work flexibility (no outside personnel required). In larger businesses, the emphasis will be on labour-saving methods and personnel management. The decision on an Astronaut milking robot will be made only after the farmer has carefully considered the integration of the robot in his daily operations.

The Lely Astronaut milking robot has been developed to increase the comfort of both the dairy farmer and his herd. A cow is given the freedom to decide for herself between milking, eating or resting. As an entrepreneur, the farmer has the management tools in his hands to improve herd management and, as a result, the profitability of the business. In addition, a milking robot offers the farmer the freedom and flexibility to improve the quality of his social life.
The acquisition of an Astronaut milking robot not only changes the method of milking, the entire operations management is also adapted. There is less “forced” contact with the cows and management is more focused on monitoring and taking direct action. Either a new barn is built or an existing barn is converted. When building or converting a barn, it is important that sufficient time is spent on the preparations. After all, the barn is intended to last a long time.

Robot milking

- The milking robot is developed to increase the comfort and the freedom of both farmer and cows.
- More kilograms of milk per worker is possible; this means a saving on labour costs and an increase in productivity.
- Change Management: from daily milking to the monitoring of data and taking direct action.
2 Business development

2.1 Introduction
The building and equipping of a barn involves many factors; not only internal factors such as management and the size of the business, but also external factors such as climate conditions and culture. Prior to constructing a barn, it is important to determine what type of barn would be in keeping with its surroundings. Not only must a barn be adapted to suit the climate, it is also important to know which products and services are available in the area and whether they are economically feasible.

Prior to deciding on how to build (or convert) a building, it would be wise to check up on the rules and regulations of the country concerned and identify any potential subsidies. Geothermal and solar energy applications are becoming popular and can be used on the farm as energy sources.

Table: the influence of external and internal factors on business development.

<table>
<thead>
<tr>
<th>External factors</th>
<th>Internal factors</th>
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</thead>
<tbody>
<tr>
<td>Legislation</td>
<td>Size of the farm</td>
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<tr>
<td>Culture</td>
<td>Future plans / objectives</td>
</tr>
<tr>
<td>Climate</td>
<td>Type of dairy farm (grazing)</td>
</tr>
<tr>
<td>Production availability</td>
<td>Strategy (organic versus conventional)</td>
</tr>
<tr>
<td>Soil</td>
<td>Management</td>
</tr>
<tr>
<td>Costs and availability of building</td>
<td>Size and breed of cows</td>
</tr>
<tr>
<td>materials</td>
<td></td>
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</tbody>
</table>
2.2 Business development constraints

The external factors (or environmental factors) determine to a great extent the opportunities for business development. There are several constraints within this framework that relate to the integration of the Lely Astronaut milking robot in the barn concept. The consequences of these constraints need to be determined before commencing the design of the barn. The individual preferences of the dairy farmer will play an important role. Prior to constructing a barn, the requirements of both animal and farmer need to be taken into consideration, both in the short and the long term.

2.3 Free cow traffic

Lely’s extensive experience in the field of robotic milking has shown that the most satisfied dairy farmers and cows are to be found on farms where free cow traffic is implemented. In addition to free cow traffic, there are also forms of forced or guided cow traffic. Free cow traffic means the animals can decide for themselves whether to visit the robot, eat or rest. From a comparison of the different dairy farms it is evident that animals in a social, free living environment – free cow traffic – soon develop their own individual and regular routines to which they all adjust. More importantly, the requirements where it concerns animal welfare are thus met: every cow is free to choose when to eat, drink, lie down or be milked. This results in healthy, active and highly productive livestock.

2.4 Methods of feeding

Milking with the Astronaut milking robot is a continuous process, with cow movement day and night. Cows feed at different times of the day; each cow has her own rhythm. Roughage of a suitable quality should be freely available throughout the entire day. Feed must be pushed up to

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Table: business development focus.

<table>
<thead>
<tr>
<th>Cow traffic</th>
<th>free cow traffic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feeding</td>
<td>stock feeding</td>
</tr>
<tr>
<td>Walking routes</td>
<td>efficient</td>
</tr>
<tr>
<td>Separation area</td>
<td>yes</td>
</tr>
<tr>
<td>Production groups</td>
<td>yes</td>
</tr>
<tr>
<td>Expansion</td>
<td>yes</td>
</tr>
<tr>
<td>Occupancy</td>
<td>normal occupancy</td>
</tr>
<tr>
<td>Grazing</td>
<td>certainly</td>
</tr>
<tr>
<td>PMR (Partially Mixed Ration)</td>
<td>Automatic feeding</td>
</tr>
<tr>
<td></td>
<td>perhaps</td>
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<tr>
<td></td>
<td>in the future</td>
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<tr>
<td></td>
<td>in the future</td>
</tr>
<tr>
<td></td>
<td>overcrowding</td>
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<tr>
<td></td>
<td>in the future</td>
</tr>
<tr>
<td></td>
<td>no</td>
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</tbody>
</table>

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Business development

- When constructing a barn, the rules and regulations of a country have to be followed, for example, a minimum distance in relation to other buildings.
- The positioning and equipping of the barn will depend on the climate, the soil conditions, the availability of materials and the culture of that particular country.
- Within the framework of external factors, the final layout of the barn is determined by long term objectives, management style and strategy.

The five freedoms for cows:

- Freedom from hunger and thirst.
- Freedom from physical and thermal discomfort.
- Freedom from pain, injury and disease.
- Freedom from fear and chronic stress.
- Freedom to express their natural behaviour.

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2.4 Methods of feeding

Milking with the Astronaut milking robot is a continuous process, with cow movement day and night. Cows feed at different times of the day; each cow has her own rhythm. Roughage of a suitable quality should be freely available throughout the entire day. Feed must be pushed up to
Ten reasons to choose free cow traffic:

- More milk per cow (more rest and higher feed intake).
- Less lameness (more rest).
- Better for low-ranking animals (less stress).
- Better fat:protein ratio (higher roughage intake).
- Higher feed efficiency (through a more frequent feed intake).
- More freedom and increased animal welfare.
- Less labour and more milk per robot.
- Less mastitis (through less stress and more frequent milking).
- Pleasant social life for the farmer.
- Lower costs (investment costs in fencing), higher return.

The feeding method used will influence the layout of the barn. Prior to designing the barn, a decision requires to be made on the method of roughage distribution and the need for concentrate pens. For barns where manual feeding is applied, or where the roughage is pushed up to the feed fence by the tractor and mixer wagon, practically any design is suitable. However, where roughage is distributed automatically, or where individual feeding is applied, it will be necessary to adapt the construction of the barn to these requirements. Stock feeding with a moveable feed fence also requires a different barn design. The amount of concentrates that the farmer intends to feed must also be taken into account. If this is more than the robot can dispense (a maximum of 8 kg (18 lb) per cow per day depending on the milking and feeding speeds), a space must be made available in the barn for one or more concentrate feed stations.

Feeding strategy

The motivation of a cow to visit the robot is not due to pressure on the udder but rather the need for concentrate feed. Therefore, to keep the animals healthy and active, it is very important to adapt the basic feed rations to their requirements. The energy level in the basic rations should not be too high, so that the low production animals also remain motivated to visit the robot. This is also known as
Successful robot milking

- Successful robot milking depends on the willingness of the cow to visit the robot and on the implementation of free cow traffic.
- The motivation of the cow to visit the robot is based on receiving concentrates (the reward).
- The ration at the feed fence must be adapted to the average milk production of the cow (rule of thumb = average production - 7 kg / 15 lb); the low-production animals will thus remain motivated to visit the robot.
- Well-planned walking routes in the barn will make work pleasanter and will increase the farmer's labour production.

PMR feeding strategy. PMR is an acronym for Partially Mixed Ration, which means that a basic mixed ration is fed at the feed fence and the main portion of the concentrate is fed to the cows in the robot. The ration at the feed fence should be adapted to the average milk production of the cow (rule of thumb = average production - 7 kg / 15 lb); the low-production animals will thus remain motivated to visit the robot.

2.5 The farmer’s walking route

Robot milking demands an individual approach to the organization and routine in the barn. In order to increase labour productivity and labour efficiency, consideration needs to be given to the farmer’s walking route before designing the barn. The farmer’s walking route is the route taken and the distance covered by the farmer when he walks through his barn, perhaps several times a day. It is important that the work is carried out swiftly, safely (biosecurity) and in a pleasant way (by one person), and that it leads to an excellent result. Make sure the robots are easy to reach and that the paths are clean and free of obstacles. Long distances to and from the robots, or to and from the computer, have a negative effect on the operation of the farm. Clean and easy access to the robot area for the farmer (and technician, visitors) will make daily maintenance of the robot pleasanter than when feed fences or slippery cattle grids have to be avoided. Also check whether the route that is taken when fetching the cows and cleaning the cubicles is clear and efficient, without having to walk back and forth to open or close gates.

The layout of the farm also plays a role. Where will the feed storage be positioned? And will the milk collection service be able to access the tank room easily? Prior to designing the barn, the layout of the farm and the location of the buildings will need to be considered.

2.6 Separation and treatment area

In many situations, the use of a straw bedded pen as a separation room to provide new or lame cows with more comfort is desirable. On large farms a separation unit with cubicles is often desired in order to make it easier to treat or inseminate certain animals. Where the treatment of animals in the herd – at the feed fence or in a separation area – is easily realised on smaller farms, on larger farms a separate treatment alley or area is desirable, for example for drying off cows. The decision whether or not to have a separation area depends on the way the farmer wishes to treat his animals and the desired amount of cow comfort. Before making a drawing of the barn, the need for a treatment and/or separation area will need to be considered.

The routing to this area can be via the robot or, in an existing situation where there is insufficient room, via a selection box to another part of the barn. A separation room in use as a straw bedded pen will ideally provide 3-4% of the livestock with an area of 10 m² (12 yard²) per animal. If the separation area is also used for insemination and treatment, the use of a self-locking feed fence is advisable. In all cases, in the separation area, sufficient fresh food and potable water should be made available.

2.7 Working with groups

When working with different groups, it is important that the existing social hierarchy within a group is disrupted as little as possible. The best results as far as labour and milk production are concerned, are achieved on farms where cows remain in the same group. The cows can then return to their own group after calving. A heifer can be assigned to the robot with the most overcapacity. In smaller groups, the animals can be brought to the robot more easily. However, the loss of a robot due to maintenance will have little effect on the movement behaviour and the number of milkings of larger groups, as the cows can use the other robots.
Working with production groups is feasible when there are two or more robots. The opinions on the composition of the groups vary somewhat. For example, a separate group of heifers could be compiled in order to increase the results, although dairy farmers do have different opinions on working with heifer groups. Some are more enthusiastic than others. The amount of milk production and the composition of the feed ration could also be used as a basis for the compilation of the groups.

In robotic milking the regular routine of the cows should be disrupted as little as possible. Changes to the production group during lactation have a negative effect on the cow. She would then have to become accustomed to another robot, a new hierarchy and a different feed ration. When working with different production groups, it is important that the dairy farmer divides the herd in proportion to the number of robots. This should be taken into consideration when compiling the groups. A group should also include cows in various stages of lactation. This method is less labour intensive. Taking all the pros and cons into account, Lely is of the opinion that the cows should be kept in the same group throughout the lactation period.

2.8 The future
Future expansion needs be taken into consideration, particularly when building a new barn. As the Astronaut milking robot is a single-box system, more units can easily be added. It is advisable, however, to take into account any plans for future growth at the start of the construction. This also applies to the planning of sufficient calving and sick pens. The ideal approach is a barn design based on twice the desired size of the farm. Build what is required now and reserve the rest for future expansion.
2.9 Occupancy

The milking robot has to process a significant amount of milk to keep the automation costs per kilogram of milk at an acceptable level. Good milking ability, healthy claws and assertive behaviour of the cows contribute to achieving this. In an overcrowded barn, cows often compete with each other for lying and eating places. This has a negative effect on their health. To make optimal use of the robot’s capacity, it is advisable to avoid overcrowding in the barn.

Grazing box viewed from above:
1. The cow has not been milked and is guided back into the barn.
2. The cow has been milked and is allowed outside. Source: Lely Industries

2.10 Grazing

Grazing and automatic milking go well together. When combining automatic milking with grazing it is strongly recommended to make use of one or more Grazeway selection boxes. The selection box is placed at the exit of the barn and will only allow the animals outside if they have recently been milked; animals that are due to be milked remain inside. This system gives the animals an extra incentive to visit the robot because they quickly learn that they are allowed outside after a visit to the robot. To ensure that the number of milkings does not decline too much after grazing has commenced, the following factors – with a view to the layout of the land and construction of the barn – need to be taken into consideration:

- A good infrastructure should be provided to and from the field with sufficient broad, flat paths that are easily accessible to cows.
- Make sure the pastures are not too far from the barn. Experience has shown that a distance of 1 km (0.6 mile) from the barn to the end of the pasture is still acceptable.
- Consider also the location of the land. Using the driest part of the plot as the entrance and exit and situating the wettest part as far back as possible will reduce trampling and increase accessibility considerably. Bear in mind that cows need to be able to walk back to the barn in a logical way.

- The selection box can be placed either inside or outside. Placing the selection box inside has the advantage that it will remain cleaner and also that the animals not yet allowed outside are more easily sent back into the barn. When building a new barn it is advisable to leave space for the installation of a grazing box. Make sure that the (mobile) manure scraper is not hampered by the selection box. If the grazing box is to be placed outside, a roof and a shallow pit for the manure disposal could be the solution to a clean environment.

- When building a new barn, the most convenient location for the barn exit(s) in relation to the land should be taken into consideration.

- Try to prevent farm traffic from crossing the cow-paths as much as possible. Take this into account when constructing the feed storage. If this is unavoidable, a barrier, cattle grid or electric wire at a height of 10 cm could be a solution.

Grazing strategies

The Grazeway selection box can be used for the so-called A-B grazing system. In this system, cows must first be milked in the milking robot prior to being allowed to go from plot A to plot B. Plot B – a new plot with fresh grass – forms the motivation for the cows to visit the robot. When 100% grazing is applied, a third plot – plot C – can be used during the night.

Another example of a grazing system is paddock grazing. This system has the negative aspect that the grass is not efficiently used. This system can be applied in three variations: unlimited, limited or siesta grazing. Siesta grazing means that cows are only allowed outside during the morning and late in the afternoon. It has, however, been proven that grazing is most effectively applied when cows have a fresh piece of grass at their disposal each time: the so-called strip grazing. A negative aspect of strip grazing is that it is labour intensive since the (electric) wire fencing has to be moved constantly. For this purpose, Lely has developed the Lely Voyager, which moves the wire at fixed times.

Whether the farmer decides to build a completely new barn on the location of his choice, or whether it is a question of an existing situation with grazing possibilities, in both cases the advice of a Lely consultant can provide the solution.
Business development constraints

- The choice of barn depends on the requirements of the farmer, for example, whether or not to have a separation room or whether or not to work with different production groups.
- During designing of the barn, management decisions, such as grazing and feeding methods, also play a role.
- During development of the barn concept, it is important to bear the farm’s objectives in mind and also to make plans for the long term (expansion opportunities).
- The Astronaut milking robot is suitable for installing in current situations and in new construction projects (with a single-box system, multiple unit expansion is possible).

Example of a time schedule for cows remaining in the barn at night:

<table>
<thead>
<tr>
<th>Time</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>06.00 AM</td>
<td>The cows can leave the barn to go to plot A. When they return from plot A, they are sent back to this plot after milking.</td>
</tr>
<tr>
<td>12.00 AM</td>
<td>Cows from plot A are sent to plot B after milking.</td>
</tr>
<tr>
<td>04.00 PM</td>
<td>The cows from plot A are led to the robot. (If the grass in plot A does not taste as good as the grass in plot B, the cows will learn from experience and they will hardly need to be fetched).</td>
</tr>
<tr>
<td>09.00 PM</td>
<td>All cows are led to the barn.</td>
</tr>
</tbody>
</table>

Grazing system

A-B grazing: > 6 kg (13 lb) DS grass

Paddock: < 6 kg (13 lb) DS grass

Using a Grazeway selection box is advised.

The motivation of the cow shifts from concentrates to fresh grass.

Example of A-B grazing systems.

Source: Lely Industries
3 Cow housing

3.1 Barn design
A barn should be seen as a system. In the previous chapter, attention was paid to a number of barn and business development constraints. However, during the development of a barn, or a barn design, management decisions, constraints and components of the barn must be seen as a whole. For example, a farmer wishing to use sand as a material in the cubicles will have a preference for a slatted floor and a manure storage. These preferences are not compatible given that the use of sand with a manure storage is not a good combination. The sand collects in the manure storage and is almost impossible to remove. In addition, the farmer should realise that work in the barn on a robot farm takes place while the cows are in the barn. The scattering of sand requires the use of large machines and, since the cows are also walking in the barn, wider paths will need to be laid out. On the other hand, sand does have positive effects on cow comfort and on claw health. The above illustrates that the barn must be seen as a coherent system and not as individual components. Farmers strive for optimum housing of their cows. Animals that feel good will produce more and be more efficient with their feed. Also, incidental health problems, such as mastitis and lameness, will be reduced. The choice of barn is, therefore, of great importance for the optimum functioning of the cows, the profitability of the farm and the well-being of the farmer.

Free stall barns
On a global scale, free stall barns are still a very popular form of housing for animals. A great advantage of the free stall barn is the low risk of contamination of the cow by manure and urine. In addition, the cow has a clean bed to lie on. In order to guarantee cow comfort in a free stall barn, the cubicles should be of adequate size. The alleys and passageways should also be wide enough so that low-ranking animals are not bullied and have unlimited access to the robot, roughage and water.
Worldwide, free stall barn are being built in a variety of designs, among others, the traditional free stall barn, but also more and more new designs, such as the cow lounge, tent barn and arch barn. It is impossible to cover all the designs in this brochure. When building a free stall barn, it is important to consider the installation of the milking robot. The walking route of the cow in the direction of the robot, feed fence and cubicles has to be logical and free of obstructions.

Loose housing systems (for example pack barns)
In most countries, the most popular form of loose housing is a pack barn on straw. In a warm, dry region with low humidity, it is possible to keep animals in a so-called compost barn – a bedding of dried manure. It is of great importance, particularly when keeping animals in a loose housing system, that they have clean access to the robot. Therefore, paving of the area in front of the robot is a necessity; a slight ascending slope in this floor will ensure that the cows no longer have straw on their legs. If the walking area behind the feed fence is also paved, 35-40% of the manure and slurry could be collected and used. From the point of view of hygiene, it is important that sufficient litter is used to keep the cows clean. The amount of litter is highly dependent on the humidity: the higher the humidity, the higher the amount of litter used.

In a compost barn, an average surface area of 7-20 m² (8-24 yard²) per cow is assumed, based on climatic conditions. A deep litter barn on straw allocates 8-12 m² (9-15 yard²) per cow. However, the cost of litter and the actions involved in sprinkling, mucking out, storing and spreading of the manure is not cheap, despite an increase of mechanisation.

The advantages and disadvantages of the different types of barn have to be weighed up. A Danish study of 36 farms has revealed that animals housed in a loose housing system showed no signs of improved hygiene, udder health or reduced disease incidence compared to animals housed in a free stall or pack barn.
### Barn design

- The barn is a system; management decisions, constraints and barn components should be seen as a whole.
- The type of barn influences the functioning of the cows, the profitability of the farm and the well-being of the farmer.
- The free stall barn is still a popular construction method; it can be implemented under almost any circumstance.
- The advantages of a loose housing system are the high level of comfort and the flexible method of construction.
- The advantages of a free stall barn are cleaner cows and suitability under virtually all weather conditions.

### 3.2 The Floor

When deciding on the type of barn and associated housing system, the floor plays an important role. On average, cows walk between 180 and 500 metres (590 and 1640 foot) a day, therefore, a good walkable floor surface is essential. The floor must be flat, dry and rough enough to:

- Prevent claw problems.
- Show signs of heat.
- Allow the animals to express their natural behaviour.
- Realise active walking behaviour in the direction of the robot.

The characteristics of the different materials and floor types must all be weighed up. The floor must be rough, but not too rough. Claws require a certain amount of wear, but excessive wear leads to lameness. It is true that on a rough, hard floor claws wear more quickly, but they also grow faster than on a softer surface. The roughness of the floor also has influence on the amount of manure that remains behind after it has been scraped. More moisture and manure is left behind on rough floors or floors with a deep profile. This makes the claws softer and more susceptible to damage.

#### Types of floor

There are slatted floors and solid floors. In conventional barns the (solid) floor is usually cleaned during milking by means of a tractor with a scraper. In robot barns this is not possible because the cows are always in the barn and the machines disturb the herd. In terms of hygiene (clean udders), a (mobile) manure scraper is recommended for both types of floor. Cleaning of the floor ensures cleaner and drier cows. Both the slatted floor and the solid floor have advantages and disadvantages. The slatted floor has a good walkable surface and efficient manure disposal.

### Table: the advantages of free stall barn and loose housing systems.

<table>
<thead>
<tr>
<th>Advantages of loose housing systems</th>
<th>Advantages of free stall barn</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improved cow comfort</td>
<td>Lower litter costs</td>
</tr>
<tr>
<td>Less risk of injury to hips, heels and knees</td>
<td>Suitable under virtually all weather conditions</td>
</tr>
<tr>
<td>Lower ammonia emissions</td>
<td>Cows are more spread out over the barn</td>
</tr>
<tr>
<td>Saving on manure storage</td>
<td>Cleaner cows mostly resulting in a lowered cell count</td>
</tr>
<tr>
<td>Flexible way of building</td>
<td>Shorter walking distances</td>
</tr>
</tbody>
</table>

Source: Adapted from DairyLogix, 2009
A solid floor is sometimes cheaper as it does not require a manure storage and, above all, less ammonia is emitted (a separate manure storage is required).

A solid floor can be installed in a number of ways; flat or sloping, with or without grooves and with or without slurry drainage. The installation of a slurry pit and a fixed manure scraper (attached via a cable, chain or rail) has a major impact on the well-being of the cow. One thing is certain: in finding her way to the robot, a cow must be able to walk over the floor with ease and confidence, and without obstacles.

Research has shown that ammonia emissions from a solid concrete floor with an incline of 3% is less than half that of a slatted floor. The costs of a solid sloping floor are higher than those of a slatted floor, and with a solid floor, the manure storage is often placed outside the barn. This will not increase the total costs. The floor can be cleaned with a scraper, but also through flushing. With this system, the floor has an incline of 3% and a large amount of water is regularly sprayed over the floor. In addition to a clean floor, this results in fewer flies in the barn, which can be a great advantage in warm climate countries.

Materials
The floor of a free stall barn can be constructed from various materials of which concrete is the most common. A barn with an asphalt or rubber top layer has a foundation of concrete. A rubber top layer is recommended for both solid and slatted floors. Because rubber dents slightly when a cow stands on it, she has more grip and will walk more confidently over the floor. Also, bruising of the sole is significantly reduced when a rubber top layer is applied. Choose a good quality rubber (for example, Compedes); a lesser quality becomes too hard under the influence of ammonia whereby the opposite effect is achieved. Compedes is made of natural rubber and is not recycled, so the rubber is softer and has a more consistent quality. In summer the manure dries up on a rubber top layer, however, this breaks up through the weight of the cow, which keeps the floor rough.

Barn floor
- A good floor is flat, dry and rough enough to enable cows to express their natural behaviour, show heat and actively visit the robot.
- Slatted floor; good walkability and efficient manure disposal.
- Solid floor; reduction of ammonia emissions.
- Rubber floors are preferable; more grip and less bruising of the soles, however, the quality of the rubber must be good otherwise the opposite effect will be achieved.
Table: advantages and disadvantages of the different floor materials.

<table>
<thead>
<tr>
<th>Floor</th>
<th>Advantages</th>
<th>Disadvantages</th>
<th>Focus Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cement</td>
<td>Cheap</td>
<td>Increase in claw problems</td>
<td>Regular roughening necessary</td>
</tr>
<tr>
<td></td>
<td>Durable</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rubber</td>
<td>Walkability</td>
<td>High purchase price</td>
<td>The rubber should be of a good quality</td>
</tr>
<tr>
<td></td>
<td>Reduction in claw problems</td>
<td>High degree of corrosion</td>
<td>The cubicles should provide sufficient comfort (otherwise cows will lie down</td>
</tr>
<tr>
<td></td>
<td>Heat observation</td>
<td></td>
<td>in the alleys)</td>
</tr>
<tr>
<td>Asphalt</td>
<td>Easy to repair</td>
<td>Walkability</td>
<td>Only implementable as a solid floor</td>
</tr>
<tr>
<td></td>
<td>Roughness</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: adapted from DairyLogix, 2009

3.3 The walls
Sufficient fresh air is essential for the removal of moist air and body heat. Therefore, the construction of the walls largely determines the way in which the barn is ventilated. Depending on the climate, the walls of a barn can be entirely or partially left open with in rainy and windy climates windbreak netting or canvas curtains that can be raised manually or automatically. In an environment with much wind, the open side of the barn should face away from the prevailing wind direction (open front barn). It should be noted that windbreak netting of a fine structure on the “exit” side of the barn can easily become clogged with dust and should be cleaned regularly. In addition, it is important to design the walls in such a way that the incoming cold air does not fall directly onto the lying areas.

3.4 The roof
The roof should be well insulated, certainly in climates with large temperature fluctuations. In cold winters a good insulation layer prevents rapid loss of the cow’s natural warmth and helps to prevent freezing of the water troughs. This insulation layer also prevents the heat of the hot summer sun from entering the roof and heating up the barn like a greenhouse.

Example of a free stall barn with partially open walls and windbreak netting.
An insulated roof prevents the warmth from entering the barn through the roof.

Insulation materials
There are various insulation materials available for the insulation of roofs and walls. Sandwich panels are prefabricated panels consisting of a steel plate on the bottom, another steel plate on the top, and a layer of insulation material (polyurethane) in between. Due to the solid structure of the panels, the metal construction of the barn can be adjusted whereby the space between the frames can increase. Dupanel panels can also be used to insulate a barn. These panels are also made from polyurethane but with aluminium on the top and bottom. Most insulation materials are comprised of synthetic products; however, there are also natural products available on the market consisting of cellulose, flax or wood. Natural materials are characterised by better moisture control. These products are available separately or incorporated into panels.

Solar panel
Roof insulation is applied to stabilise the climate in the barn. However, the sun’s rays shining on the roof can also be captured through solar panels and used to generate energy. The solar panels are mounted on the roof of the barn. A large solar panel weighs approximately 15 kg (33 lb) and can be mounted on the roof with special tape.

Roof ridges
Ventilation can be obtained through various openings in the roof. The various types of roof ridges are: open ridge, Venturi ridge, raised ridge cap and overshot roof. A roof ridge can be installed that is fully or partially open, creating a chimney effect for the air in the barn. In barns with open sidewalls, this effect is especially important during the colder winter months when the sidewalls are often closed with canvas curtains. During the summer months, transverse ventilation is the most common means of controlling the barn climate and the role of the roof ridge is then limited.

A ridge opening of 5 cm (2 inch) is advisable per 3 metres (10 foot) of barn width. An open roof ridge must not be installed directly above the feed fence. Heavy rainfall in combination with hard winds could cause rain to enter the barn through the ridge and soak the roughage at the feed fence. A gutter under the ridge will collect and drain off the rainwater. The two roof sections can also partially overlap each other in order to create an opening to allow warm air to escape. The advantage of this type of ridge is that rain is prevented from entering the barn. A raised ridge cap is where the ridge is raised above the two roof sections. Also here, rainfall is prevented from entering the barn. In areas with snow, the raised ridge cap should be large enough to prevent the invasion of snow through turbulence. A Venturi ridge cap creates extra space at the top of the barn. In this way, more air is circulated to the top of the barn. It can be compared to a loose chimney on top of a house.
Translucent panels in the roof provide natural light in the barn, which means a saving on the costs of artificial lighting (lamps). However, in bright sunshine translucent panels will warm up the barn much faster. This can be avoided by the installation of large open sidewalls through which daylight, but not direct sunlight, can enter.

**Water drainage and collection**

Depending on the climate and annual rainfall, the roof should be adjusted so that rainwater can be properly drained and eventually reused. The quality of the water determines whether and for which purpose the rainwater can be used. Rainwater collection is limited since standing water is subject to decay. Hygiene also plays a role in the reception of rainwater, and this is difficult to guarantee.

### 3.5 Manure storage

Various types of manure storage are available depending on the type of floor used. With a slatted floor, slurry is collected and stored in the manure storage. Financing of the slurry pit is included in the barn construction, which is often advantageous. The installation of a slurry pit represents a major expense in the construction of a barn. With solid floors the manure storage is often placed outside the barn. The manure can be stored in silos of cement, wood or steel. In addition to these permanent forms of manure storage, a manure bag can also be used. This is a mobile manure container and can be placed where needed. Some countries have manure lagoons. The disadvantage of a manure lagoon is the possibility of odour nuisance and rainfall.

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**Walls and roof**

- Barns may be entirely or partially equipped with windbreak netting or canvas – whether operated by an automatic climate control system or otherwise.
- Insulation of the roof against both the cold and the heat is worthwhile, depending on the temperature fluctuations per country/region.
- The roof ridge forms an important part of the ventilation system of the barn.
- When building a barn, the method of manure storage should be taken into consideration.

---

Performance of various ridge openings.  

Source: adapted from Graves and Brugger, 1995

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<table>
<thead>
<tr>
<th>Open ridge</th>
<th>Short upstand</th>
<th>Ridge cap</th>
<th>Ridge cap with upstand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Precipitation sometimes catches or falls into building.</td>
<td>Deflects blowing precipitation above the ridge, but some falls into the building.</td>
<td>Falling precipitation runs off, but blowing precipitation hits under the cap and falls into the building.</td>
<td>Both falling and blowing precipitation is deflected from the building. Provide adequate clearance to prevent blockage of airflow.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Inside gutter</th>
<th>Overshot roof</th>
<th>Overshot roof with upstand</th>
</tr>
</thead>
</table>
| Gutter collects precipitation that falls into building. | A: Blowing precipitation from this side is deflected.  
B: Blowing precipitation from this side enters building.  
Falling precipitation runs off. | A: Blowing precipitation from this side is deflected.  
B: Both falling and blowing precipitation is deflected from the building. Provide adequate clearance to prevent blockage of airflow. |
4 Layout of the barn

4.1 Inside dimensions of the barn
Sufficient space for the cattle to move around in the barn is one of the main conditions of successful robotic milking. Not only are the dimensions of the passageways important, the overall routing in the barn should also be well-organized. Low-ranking animals should be able to avoid high-ranking animals.

4.2 Lying area
Research shows a clear correlation between the amount of time a cow rests (lying down) and the milk production. In a cubicle with optimal cow comfort, highly productive animals rest 12 to 14 hours a day. Research shows that cows produce more milk (1-1.5 kg / 2.2-3.3 lb) per additional hour of rest lying down. Thus, comfortable bedding is of great importance for healthy and productive livestock.

Relationship between rest and milk production.

Source: Grant, 2007
An animal requires sufficient space to be able to drink undisturbed. Place water troughs outside the cubicle, out of the way of the busiest cow traffic.

Lying down has a higher priority for cows than eating and social interaction. This applies to animals at the beginning and at the end of the lactation period. Animals that are not given sufficient opportunity to lie down will be more inclined to wait until they can lie down rather than eating. This can lead to a lower feed intake. Sufficient and easily accessible cubicles (one per cow) are, therefore, very important.

There are three important things to consider when designing cubicles: the dimensions, the partitions and the bedding. Cubicle dimensions should take cow comfort and hygiene into account. The larger the cubicle, the higher the cow comfort. However, if the cubicle is too large it will become increasingly soiled, as will the cow and her udder. The cleaner the cubicle, the cleaner the cow. When determining the ideal length and width of the cubicle, a balance will need to be sought between cow comfort and hygiene.

### The importance of lying down:

- Potentially higher milk synthesis through better blood circulation in the udder.
- More effective rumination.
- Less strain on the claws (and claws in a drier environment).
- Less lameness.
- Higher feed intake.
- Better blood circulation of the uterus at the end of the lactation period.
- Less stress.

### Table: guidelines for barn dimensions.

<table>
<thead>
<tr>
<th>Description</th>
<th>Dimensions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between the robot and the first obstacle:</td>
<td>&gt; 5 metres</td>
</tr>
<tr>
<td>Between two rows of cubicles:</td>
<td>3.0 metres</td>
</tr>
<tr>
<td>Behind the feed fence:</td>
<td>4.0 metres</td>
</tr>
<tr>
<td>Passageway:</td>
<td>2.0 metres</td>
</tr>
<tr>
<td>Passageway with water troughs:</td>
<td>4.0 metres</td>
</tr>
<tr>
<td>Number of passageways:</td>
<td>1 per 20 cubicles in two-row barn</td>
</tr>
<tr>
<td></td>
<td>1 per 15 cubicles in three-row barn</td>
</tr>
</tbody>
</table>

1 metre = 3.3 foot

**Cubicle dimensions**

A field of tension will always remain between hygiene and cow comfort when determining the ideal dimensions of a cubicle. The ideal dimensions of a cubicle for Holstein cows of an average size are 1.25 m (4.1 foot) wide and 2.75 m (9 foot) (head to head or head towards the alley) or 3.25 m (10.7 foot) long (against a wall). These lengths are necessary in order to provide the cow with sufficient head room. The head is used as a counterweight for the cow’s hindquarters and thrust far forward when lying down or standing up. This means that there should be no obstacles up to a height of 1 m (3.3 foot). The cubicle should offer the animal sufficient space in which to lie down and rise again in the normal fashion without the risk of damage to the teats.

A minimum height of the bedstead of 15 cm (6 inch) will ensure that the cows remain significantly cleaner. When working with a manure scraper, a minimum height of 18-20 cm (7-8 inch) is recommended. An incline of the cubicle floor of 2% is ideal.
BARN DESIGN FOR ROBOTIC MILKING

Straw pen
Close-up dry cows
Straw pen
Separation area and attention cows

Example of a barn drawing with one milking robot with a split entry. Source: Lely Industries

Exit points dimensions cubicle (sketch)
≥ 3 times/day cleaning
≥ 1 metre = 3.3 foot

Calving pen
Straw pen
Close-up dry cows
Straw pen
Separation area and attention cows

Knee barriers
Cows have the tendency to crawl to the very front of the cubicle, with soiling of the cubicle as a result. This can be prevented by installing a knee barrier. The knee barrier is a rounded edge that is placed at a minimum distance of 1.80 m (5.9 foot) from the rear edge, and a maximum height of 15 cm (6 inch). Cows like to lie with their front legs over the edge. The more comfortable they are, the longer they lie down and, as a result, the more milk they produce.

Shoulder barriers
The correct positioning of the shoulder barrier is very important in enabling cows to lie down and stand up easily. For this the animal must be able to stand on its four legs in the cubicle without being hindered. It is advisable to place the shoulder barrier perpendicular to the knee barrier at a height of 1.25 m (4.1 foot).

Cubicle partitions
A good cubicle partition should meet certain conditions. It is important that the cow is not hindered by the cubicle partition when she lies down or stands up. Also, the cubicle partition must not cause injury to the animal; the dimensions of the cubicles must, therefore, be accurate.
Cubicle dimensions

- The inside dimensions of the barn are very important in realizing optimal cow traffic to the robot; a minimum space of 5 metres (16.4 foot) from the robot to the first obstacle is necessary.
- Highly productive animals should rest 12 to 14 hours each day to achieve the optimum milk production – the dimensions of the cubicle play an important part in this regard.
- Cubicle dimensions: 1.25 metres (4.1 foot) wide, 2.75 metres (9 foot) (head to head) or 3.25 metres (10.7 foot) long (against a wall); if necessary, a knee barrier can be installed.

Cubicle bedding

The choice of cubicle bedding is not easy. It is of paramount importance here that the cow is able to lie down comfortably and rise again easily. From this point of view, deep litter cubicles of sand, straw or sawdust are preferred. Other options are a waterbed, a cow mattress or rubber mat. In order to determine the most agreeable cubicle bedding, the “cow comfort test” can be applied. When lying down a cow first transfers a large part of her weight onto her knees and then gradually lowers herself down. The farmer can imitate this effect by standing in front of a cubicle and “falling” four or five times with his full weight onto his knees. If this is not uncomfortable to him, the bedding in the cubicle will be comfortable for the cow.

The cubicle should be cleaned several times each day and (with the exception of bedding consisting entirely of sand or compost) clean sawdust or chopped straw will require to be provided. It is recommended to use 0.7-1 kg (1.5-2.2 lb) litter per cubicle per day. This amount is sufficient to keep the boxes – and thus the cows – clean and dry. The use of white sawdust is preferred. Red sawdust absorbs less moisture and its hard texture makes it is less comfortable to lie on.

The amount of litter used and the temperature of the barn affect the extent to which cows experience cubicle beddings. At low temperatures (< 0°C / 32F) cows prefer a bed of straw or a mattress with 5-7 cm (2-3 inch) rubber padding because these feel warm. A waterbed is avoided at low temperatures because it dissipates too much body heat. At high temperatures (> 30°C / 86F) the cows have a preference for a bedding entirely of sand or compost. These beddings do not feel warm and body heat is rapidly dissipated.

In a deep litter cubicle, approximately 10 m² (12 yard²) lying space per animal is required. Calculate an additional 15 m² (18 yard²) for the concrete floor in front of the robot. When calculating the straw requirement it is recommended to use between 8 and 12 kg (17.6 and 26.4 lb) of litter per cow per day (cow’s annual production / 1,000).

In warm climate countries, such as Israel and some parts of America, so-called compost barns are becoming increasingly popular. The lying area of compost barns is ploughed to a depth of approximately 25-35 cm (10-14 inch) twice each day to mix the manure and the urine and to keep the bedding aerated. A disadvantage is that twice daily churning of the compost creates unrest in the herd. For this reason, cultivation of the soil should take place at a time when there are very few animals lying down, for example, directly after feeding. The movement behaviour of the cows towards the robot is then disrupted as little as possible. As long as the compost is dry, microbiological activities will help to process the manure. A layer of sawdust can be added every 2 to 5 weeks. In a compost barn, a lying space of 7-20 m² (8-24 yard²) per cow is required. There must be sufficient ventilation to keep the compost barn dry and to stimulate the composting process (temperature >40°C / 104F).

![A cow in the process of lying down. Source: adapted from Schnitzler, 1971](image-url)
Table: advantages and disadvantages of the different kinds of cubicle bedding.

<table>
<thead>
<tr>
<th>Cubicle Bedding</th>
<th>Advantages</th>
<th>Disadvantages</th>
<th>Focus Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deep litter sawdust</td>
<td>Comfortable when spread generously</td>
<td>More work to keep clean</td>
<td>Optimum ventilation</td>
</tr>
<tr>
<td></td>
<td>Less injuries to heels and hips</td>
<td>Higher litter costs</td>
<td>Increased risk of coliform mastitis in wet/soiled sawdust</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deep litter sand</td>
<td>Little bacterial growth</td>
<td>Sand on the floor causes wear on the manure scraper</td>
<td>Cubicles must be kept level</td>
</tr>
<tr>
<td></td>
<td>Bedding remains dry</td>
<td>Sand collects in the manure pit (investment needed for solutions,</td>
<td>Top layer of sand (15 cm / 6 inch) must be nice and loose</td>
</tr>
<tr>
<td></td>
<td>Sand on the floor gives the cow more grip</td>
<td>also with regard to mixing and spreading of manure)</td>
<td>Maintenance of robot, e.g. shorten strings on the teat cups sooner to</td>
</tr>
<tr>
<td></td>
<td>High cow comfort</td>
<td></td>
<td>prevent failures due to cracks</td>
</tr>
<tr>
<td></td>
<td>Cool in warmer climates</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lower cell count and less mastitis</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>No heel injuries</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Drier claws</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Waterbed (double rooms)</td>
<td>Lower litter costs</td>
<td>Purchase price</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cows have to adapt to bedding</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mats</td>
<td>Lower litter costs</td>
<td>Uncomfortable</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hardens relatively quickly</td>
<td></td>
</tr>
</tbody>
</table>

Source: adapted Zevenbergen, 2005; DairyLogix, 2009

Cubicle bedding

- In all cases the bedding in the cubicles must be clean, dry and comfortable.
- Cubicle bedding can include straw, sand, sawdust, waterbed, mattress or rubber mat.
- There are specific compost barns in warm climates whereby (dried) manure forms the bedding of the barn.
- The amount of litter is dependent on the temperature and the humidity; cows should always be able to lie in a clean, dry cubicle.

4.3 Feed fence and feed alley

The feed fence is used in the barn as a partition between the feed alley and the walking/eating area. Feed fences are available in various shapes and sizes: from self-locking feed fences to the placing of a cable or bar to keep the cows in the barn area. It is essential to have feed places, with a minimum width of 65 cm (26 inch) per animal. The top bar of the feed fence must be high enough to avoid injuries and irritation of the shoulders.

It is advisable to place the feed alley at least 10-15 cm (4-6 inch) higher than the barn floor to avoid the animals from having to reach too far for their feed. This will cause injury to the shoulder and also it will not be advantageous to the lifespan of the feed fence. Tilting the feed fence towards the feed alley could also increase the reach distance of the animals. In addition to a good feed fence and feed alley design, frequent pushing up of feed is necessary in order to stimulate frequent robot visits and sufficient feed intake.

A self-locking feed fence, a diagonal feed fence and a “free” feed fence.
Feed fence and feed alley

- Ensure sufficient eating places (for example one eating place per cow) with a minimum width of 65 cm (26 inch).
- There are various feed fence designs; it is important that the cows cannot injure themselves on them and that they do not incur skin lesions.
- Regular pushing up of feed encourages good feed intake and frequent robot visits.

4.4 Water supply

Cows need plenty of moisture. Part of this moisture is absorbed through the intake of roughage and the other part through fresh water. The importance of potable water intake is often underestimated. When the water is not fresh, a cow drinks less. She will then be unable to reach optimum production levels. To enable low-ranking cows to drink undisturbed, it would be wise to place two water troughs in each group. High-ranking and low-ranking cows can then drink at the same time. An area of 10 cm² (1.6 inch²) per animal, divided over one drinking place per 15 to 20 animals is sufficient.

The optimum height of a drinking trough is approximately 60 cm (24 inch) above the floor. A cow needs a trough length of approximately 60-100 cm (24-39 inch). The water supply must be adapted to the drinking speed of the cow. The average drinking speed of a cow is 5-8 litres per minute (1.3-2.1 gallon/min); a thirsty cow can drink as much as 24 litres (6.3 gallon) per minute. Ambient temperatures also affect water intake. When the temperature rises water intake increases.

There are various kinds of water troughs on the market; “standard” troughs, tilting troughs and thermo-troughs. Cows prefer open water troughs. The so-called thermo-troughs are sealed off with a rubber ball, which makes them virtually frost-free. However, the ball inhibits the intake of water, becomes dirty easily and there is relatively high water loss. A “standard” water trough or a tilting water trough is, therefore, preferred. In addition, tilting water troughs or water troughs with a removal stopper at the bottom are easy and quick to clean with the aid of a brush.

To keep water in a “standard” or tilting water trough frost-free, it can also be heated through a circulation system. Heating of the water is easily accomplished in combination with a pre-cooler. The pre-cooler keeps the milk cool and generates warm drinking water. This saves energy and leads to lower cooling costs. This option must be disabled, however, when the main cleaning of the flushing system starts, as it could be negatively affected. To ensure the water does not become too warm, the trough should always be placed in the shade. Drinking troughs should be regularly cleaned out so that cows always have access to clean, fresh water.

<table>
<thead>
<tr>
<th>Weight (kg) of product level</th>
<th>Water intake (l) during different ambient temperatures</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>5°C</td>
</tr>
<tr>
<td>Calf</td>
<td>90</td>
</tr>
<tr>
<td>Calf</td>
<td>180</td>
</tr>
<tr>
<td>Yearling</td>
<td>360</td>
</tr>
<tr>
<td>Heifer</td>
<td>545</td>
</tr>
<tr>
<td>Dry cow</td>
<td>630</td>
</tr>
<tr>
<td>Lactation cow</td>
<td>9 kg/day</td>
</tr>
<tr>
<td>27 kg/day</td>
<td>84</td>
</tr>
<tr>
<td>36 kg/day</td>
<td>103</td>
</tr>
<tr>
<td>45 kg/day</td>
<td>122</td>
</tr>
</tbody>
</table>

1 Celsius = 33.8°F, 1 kg = 2.2 lb, 1 l = 0.26 gallon

Table: effect of ambient temperature on the water intake. Source: Top Agrar, 1998

A tilting water trough facilitates refreshing of the water and cleaning out of the trough.
Water supply

- A cow needs 10 cm² (1.6 inch²) of drinking space at a water trough suitable for 15-20 animals.
- The water supply must be adapted to the speed at which cows drink; water is important for the metabolism and thus the milk production of a cow.
- Installation of water troughs in the vicinity of the robot is preferred; cow traffic, however, should not be hindered.

The best place for the water trough is in the immediate vicinity of the robot. A cow that has just been milked likes to drink in order to restore her osmotic balance. Make sure there is sufficient space around the drinking trough to avoid passing cows from hindering the animals that are drinking. Conversely, cows wishing to be milked must be able to reach the robot without problem. Water troughs should not be placed in dead end alleys, as low ranking animals will not be given sufficient opportunities to drink.

4.5 Ventilation

In addition to feed, water and comfortable bedding, cows also require fresh air thus the barn should be well ventilated. Good ventilation means that gasses, warmth and moisture are adequately removed and sufficient fresh air is supplied. The amount of warmth produced by cattle determines, to a great extent, the ventilation requirement. Good ventilation is also essential for reducing the transmission of pathogens.

Most cattle barns are ventilated naturally. The size of the inlet and outlet vents determines the ventilation capacity. Always build a barn transverse to the dominant wind direction as this guarantees good, natural cross ventilation. The use of open facades in combination with, for example, wind break netting or curtains for closing off the opening, has already greatly improved the ventilation of many cattle barns. For higher outdoor temperatures it is advisable to support natural ventilation with mechanical systems. A well-insulated roof also ensures a better indoor climate, both in hot and cold weather.

Cows with optimum production levels have a great need for fresh air in order to dispose of their body heat. Therefore, it is better to think in terms of m³ (1.3 yard³) air per litre of milk than in m³ (1.3 yard³) air per cow. When calculating in m³ (1.3 yard³) per litre of milk it becomes immediately obvious that the need for fresh air increases when production increases. There are practical examples of companies where, after an increase in milk production, problems arose with the somatic cell count (SCC) levels. Insufficient ventilation was often found to be the cause.

In an area with a temperate climate, leaving the barn walls open in combination with the use of windbreak netting or canvas can often provide sufficient ventilation. In an area with cold winters and hot summers and/or high humidity, tunnel ventilation could be an option. This type of ventilation refreshes the air through pressurization. Given the specific requirements in different climates, it is recommended to involve a local expert to obtain more advice.

Example of a barn with tunnel ventilation.

Heat stress

The comfort temperature of a cow lies between -5 (23F) and 18°C (64.4F), but also temperatures to -10°C (14F) are well tolerated by highly productive cows. At such temperatures, measures are usually required to be taken in order to keep water frost-free. However, cows have more difficulty with higher temperatures. Cows experience a mild form of heat stress at temperatures of 20°C (68F) and a relative humidity of 80%, resulting in a decrease of dry matter intake and, consequently, milk production. Sufficient fresh air is important for the removal of moist air and body heat.
Effect of temperature and relative humidity on stress levels in cows.

<table>
<thead>
<tr>
<th>Temp. (°C)</th>
<th>Lethal</th>
<th>Severe heat stress</th>
<th>Heat stress</th>
<th>Mild heat stress</th>
<th>No stress</th>
</tr>
</thead>
<tbody>
<tr>
<td>45</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>41</td>
<td></td>
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<td>33</td>
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<tr>
<td>21</td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

Relative humidity (%)

Source: adapted from Wiersma, 1990

To avoid heat stress, water can be sprayed in the area above the cows to cool the warm air. Spraying water on a non-insulated roof can also reduce the temperature in the barn. Another option is to wet the cows with a fine spray. This is fairly easy to achieve through spraying the backs of the cows above the feed fence using a hosepipe and nozzle. However, this is conditional upon the use of ventilators in the barn to avoid raising the air humidity. Pay attention to droplet size because a fine spray can also result in insulation. Fogging systems work best with a timer so that the cows are sprayed at regular intervals. It encourages the animals to come to the feed fence and helps to increase feed intake.

4.6 Foot baths

The economical effect of claw disorders is considerable, especially on robot farms. The milk production, fertility and visiting behaviour will be lower as a result of claw disorders on the farm. In addition, claw disorders have a negative effect on the welfare of the animal. To improve claw health, footbaths are recommended.

There are various types of foot baths available. A foot bath with a sponge is preferred for two reasons; firstly, the sponge prevents the cow from slipping and, secondly, it minimizes the loss of fluid in the foot bath.

There are three ways of installing a foot bath on robot farms:
- A temporary foot bath positioned behind the robot exit. This is relatively easy to set up and all the cows will be forced to walk through it. A decline in robot visits will be observed initially but this will not be for long.
- A temporary foot bath set up in a logical position in the barn where the cows are quietly driven through. This option will cause a brief disruption to cow traffic.
- A permanent foot bath used occasionally will have a calmer effect on the herd. On the other hand, a permanent foot bath is often a source of infection since it is difficult to clean.

Ventilation

- Cows generate a lot of heat – refreshing the air and good ventilation is, therefore, of great importance.
- Various methods can be used for cooling cows: natural ventilation, mechanical ventilation, tunnel ventilation or cooling through the spraying of water.
- Cows suffer relatively quickly from heat stress; a temperature of 20°C (68F) and a relative humidity of 80% cause mild heat stress.
The importance of foot baths and lighting

- The application of foot baths is important and in the long term will ensure a sustainable and active cow.
- Foot baths can be installed in various places in the barn, however, they will lead to a temporary disturbance of cow traffic.
- Milk producing cows need a light regime of 16 hours of light and 8 hours of darkness.
- For dry cows and heifers, a daylight period of 8 hours is sufficient.

A number of other matters should also briefly be mentioned:
- A scratching brush for cows. Cows react positively to the presence of brushes. There are various kinds available, from a simple broom fitted with a spring-loaded device, to an electrically driven brush, such as the Lely Luna Cowbrush.
- The availability of salt blocks.
- A room for receiving visitors.
- Housing of young cattle. The housing of youngstock will be covered in more detail in the brochure ‘Breeding youngstock’.

A temporary foot bath behind the robot exit is easy to install and keep clean. A decline in the number of visits by 0.5 per cow per day (depending on the quality of the foot bath and the behaviour of the cows) should be taken into account. The placing of a temporary foot bath in a strategic place will be more labour intensive for the farmer, since the cows will have to be driven through the foot bath. The choice of foot bath will depend on the farmer, the cows, the structure and the layout of the barn.

To set up an effective foot bath, the following considerations need to be taken into account. A foot bath should have a minimum depth of 15 cm (6 inch) to allow the claws to become completely submerged in the liquid. The length of the foot bath should measure 3 metres (10 foot) so that each foot is submerged twice. The width will depend on where the footbath is installed, but cows should not be able to walk past it.

4.7 Lighting

Good light management is important to the cow’s milk production. A “long-day photoperiod” (LDPP) means an exposure of 16 hours (>150 lux) to continuous light followed by a period of 8 hours of continuous darkness. Milk producing cows in a barn where the LDPP method is applied, show a consistent increase in production of 8-10%, irrespective of their historical production levels. For optimum results, the LDPP programme should be enabled immediately after calving.

For dry cows and heifers, the exact opposite applies. Here, a longer light regime is less important and daylight periods of 8 hours with less light intensity are sufficient. Through the establishment of a lighting plan, it is possible to determine beforehand what lamps are needed to obtain optimum lighting in the barn. Light is especially important for cows and will therefore be calculated largely from the perspective of the cow. This means: sufficient lighting in the barn, however, too much light in the alleys or in other areas is not necessary. A lighting plan should also specify the best places to install lamps in order to gain the most effect from the light.

Avoid unnecessary burning hours by applying the advanced L4C switching technique. The lamps are switched on and off according to indoor and outdoor light intensity. An optimum level of light is thus created for animal and mankind.
Detailed example of barn lay-out: the numbers refer to paragraphs in this chapter.

Source: Lely Industries
The barn layout – an elaborated plan

5.1 Robot area
Dairy farmers try to achieve the most favourable layout of the barn whereby space is optimally utilized. The robot control room should be in a secure area (vis-à-vis safety and undesired visitors), with the robot situated next door, protected by easy to clean floor, ceiling and walls. This area should have running water, good lighting but also ventilation to keep the control room fly-free in the summer; this can be achieved through a wall or ceiling ventilator. Insulated walls and ceilings will keep the robot control room frost-free in the winter.

The entrance to the control room should be clean and dry and inaccessible to cattle. It is important to keep this area clean and to avoid dragging manure and the associated diseases of adult animals into the calf area (for example when collecting colostrum). The control room can be reached via the feeding alley or from outside. This is also important for the Service engineer, thereby minimizing the spreading of disease. This clean entrance is compulsory, and in some countries it is a legal requirement.
Where permitted, the use of a passageway that crosses the clean entrance could be very useful as a cow-route to or from a separation area behind the robot. The total width of 90 cm (35 inch), at floor level just 75 cm (30 inch), of this passageway will allow the farmer to easily step over it and enter the robot area clean.

A small passageway alongside the Astronaut milking robot – too small for cattle but wide enough for the farmer – enabling easy access from the control room to the cattle area, is very convenient for the farmer (maximum 32 cm/ 13 inch). An optimal size for a robot area is 3 x 5 metres (10 x 16 foot). In addition, it is advisable to keep a hosepipe handy to clean boots before entering the control room. A door that opens out, or a sliding door, will not reduce the robot area and will prevent hindrance and annoyance. In the rare instance of a cow entering the robot room, a door measuring 90 cm (35 inch) wide will allow her to easily return to the herd.

The robot room should avail of:

- Running water.
- Good lighting.
- Ventilation.
- Easy to clean floor, walls and ceiling.
- Clean access (compulsory in many countries).
5.2 Separation area

A separation area, preferably equipped with cubicles or as a straw bedded pen, is an area that can be used for the short-term treatment of animals, such as insemination, or when they require extra attention, such as new or lame cows (a bedding of straw is preferable). The separation area should be positioned in such a way that the straw bedded pen can easily be mucked out.

The routing to this area can be via the robot, the Grazeway or the animal can be led by hand. A separation area designed as a straw bedded pen will ideally provide 3-4% of the herd with an area of 10 m² (12 yard²) per animal. If the separation area is also used for insemination and treatment, the use of a self-locking feed fence is advisable. In all cases, sufficient fresh food and drinking water should be made available in the separation area.

Farmers working in milking parlours often believe they cannot do without a separation area. Robot farms implement different working methods. Many farms have built separation areas that have never been used. It would probably be more practical to make the separation area part of the barn through the installation of cubicles, so that it is not just wasted space.

5.3 Treatment box

A good treatment box is indispensable in achieving labour efficiency and convenience on the farm. The basic principle should be that an animal can be treated easily, quickly and safely by one person. This can be accomplished through centrally positioning the treatment box - in or near the separation area - and through the clever use of flexible fencing. In this way, animals from different groups can be treated and eventually rehoused.

The various walking routes (the routes taken by the farmer through the barn) and flows on the farm should be taken into account: human, animal, manure and feed flows. This will prevent the “clean” and “dirty” flows from crossing and thereby the risk of contamination from increasing. This is a significant advantage of a barn with feed alleys along the side: all animals can reach the treatment area without having to cross the feed alley. A permanent treatment area also means that all medication and materials required for the treatment are at hand, as well as the entrance to the T4C management system where the correct registration of every treatment takes place. A second PC accessible while wearing work boots, is certainly a plus.

5.4 Calving area

The location of the calving area is the first priority; the best place is immediately next to the close up dry cow group. Cows that calve unexpectedly can then easily and quickly be moved. The second priority is access to the feed fence: in the calving area the animals must have access to fresh roughage and fresh drinking water. To save on labour, a third priority would be to position the calving area in such a way that animals that have calved can easily be brought to the robot and back to the calving area or separation room (straw bedded pen). Visual contact between the cows in the calving area and the herd is
advisable due to the stress-reducing effect on the calving animals. The calving area should, with a regular calving pattern, house 3% of the herd. The animals should have sufficient lying places and space is also required in the event of assisted deliveries. An area of 12-15 m² (14-18 yard²) per animal, with a minimum length of 4 metres (13 foot), is recommended.

5.5 Dry cows
Even with a milking robot it is important to consider the housing of dry cows (they are often housed in the same barn as the dairy cows). Make sure that the milk producing cows visiting the robot are not hindered by this group. This is of particular concern in combination with grazing. Usually, this means that dry cows in the same barn are conveniently housed behind the robot. If the dry cows are housed in another barn, it is important to consider how they are brought back and forth. Preferably one person should be able to do this efficiently.

Outdoor run with sand
Highly pregnant cows need exercise in order to counteract fatty liver. A slatted floor does not offer a cow in the last weeks of pregnancy sufficient grip to be able to walk around enough. In a sizeable outdoor run with (yellow) sand and good permeability, a cow can get sufficient exercise. Additional exercise will stimulate feed intake on the day of calving and the following days, thus reducing the risk of fatty liver. Fewer cows will suffer from retained placenta and more cows will have a smooth begin to the lactation period. In addition, sand provides better lying comfort and more grip than a cubicle, whereby cows are more easily able to stand, move and lie down.

5.6 Sick pens
The separate housing of new cows in a straw bedded pen with free access to the robot will ensure a smooth and stress-free start to the new lactation. This will help to prevent problems later on. The straw bedded pen can also be used for the housing of weak, sick or lame animals. This area should be comfortable and easy to muck out. Also here, adequate space, fresh feed and drinking water should be freely available to the animals. As a rule of thumb, new cows and attention cows account for 5% of the herd. As with the calving area, it is recommended to situate the sick cow pens close to the milking robot, thus enabling the animals to find their way to the robot and back without difficulty. Never combine the calving pens with the sick pens and never use the calving pens as sick pens!

5.7 One-way gates
The use of gates in robotic milking should be limited as much as possible. It is sometimes necessary to place a one-way gate, for example in order to prevent cows from entering the robot from the exit side. A great advantage of one-way gates is that they immediately close after the cow has passed through. Furthermore, cows quickly learn how to pass through these gates.

5.8 Tank room
The milk storage area must be kept clean and tidy at all times. The interior of the tank room very much depends on local regulations. In this paragraph, a general description of an interior is described. A simple and easy way to achieve this is by using the tank room exclusively for the storage of the tank(s). Furthermore, it is self-evident that for the floor, walls and ceiling, materials should be used that are easy to clean, so that the room is easy to keep clean. Also, in the interest of good hygiene, it is important that the tank room is well ventilated and that the drains are fitted with a stench trap.
A well-paved approach road to the farm and good accessibility of the tank room will make it more convenient for the milk collection service and will promote general hygiene on the farm. When the milk storage tank has been emptied, it is subsequently cleaned. To prevent the robot from becoming idle during cleaning of the milk tank, it is advisable to install a so-called buffer tank. The milk is stored in this vessel during cleaning of the cooling tank.

Pre-cooling and heat recovery
The pre-cooler is applied in order to use the warmth of the milk and save on energy when cooling the milk – up to 40%. The pre-cooler is based on the counter flow principle whereby two fluids pass each other in opposite directions. This principle is applied in a plate cooler or in a tube cooler. The heated water is extremely suitable as drinking water for the cows but it can also be further heated for use in the cleaning cycle. Depending on the system, 0.8 litres (0.21 gallon) of water can be heated to 55°C (131°F) with 1 litre (0.26 gallon) of milk.

5.9 Machine room
The compressor should be placed in a separate and well ventilated room. The compressor could also be placed in the office, since it is quiet and it will also keep the office warm in the winter. With a new building, consideration could be given to placing the tank and the machine rooms completely outside the barn. This will make it easier for future expansion; the space in the barn can be more efficiently arranged and there is often a better access to the straw pens for mucking out.

5.10 Hygiene sluice
The Astronaut milking robot is receiving much attention from farmers who have not yet made the switch. Furthermore, visits to the farm will be made by inspection agencies, such as veterinarians and the inseminator. To counteract disease, a hygiene sluice is a necessary condition. Here, visitors can change and disinfect their footwear. The hygiene sluice must be immediately recognizable to visitors upon arrival at the farm. There must be a facility for cleaning boots at any place where there is a transition from a dirty to a clean area. A set of brushes with a water connection and a drain will suffice. Even when the farmer goes from the dairy cows to the young cattle, his boots should be cleaned to prevent the spread of disease.

5.11 Holding area
When planning the layout of a barn, a number of other factors play a role. For the animals that – for one reason or another – do not visit the robot on their own accord, a holding area can be created. This could be a flexible holding area made up of a number of fences to create a temporary holding area. When all the animals that have been fetched have visited the robot, the fences can be removed and the robot becomes accessible again. There is also an automatic fence that opens at a signal from the robot. This flexible holding area has the added advantage that the animals can visit the robot without being hindered by the dominant animals. A disadvantage is that the robot is temporarily inaccessible to cows that visit the robot voluntarily. It is, therefore, advisable to have a flexible holding area for groups in combination with more robots, so that at least one robot remains accessible to the other cows.

One robot group can use a permanent holding area and split-entry to the robot. This will allow animals in the herd continuous access to the robot. A disadvantage is that low-ranking cows that have been fetched could be waiting a long time in the holding area.
5.12 Concentrate feed station
During a visit to the robot a cow can eat 2.5 kg (5.5 lb) of concentrate while she is being milked. It is known from experience that a minimum of 2 kg (4.4 lb) of concentrate is needed to encourage cows to visit the robot. The maximum amount of concentrate dispensed is approximately 8 kg (17.6 lb) per cow per day. For animals requiring more than 8 kg (17.6 lb) of concentrate, one or more concentrate feeding stations (Cosmix) can be placed in the barn. Do not place extra stations in the direct vicinity of the robot in order to avoid too much cow traffic in front of and near the robot. Animals that wish to visit the robot are then hindered as little as possible by their congeneres.

5.13 Office
It is strongly advised to have an office in the barn to make it easier to carry out the necessary administration and to increase efficiency. The size of this area will depend on the activities carried out by the farmer in the barn. A lockable cupboard with a computer could be installed where a number of changes to the T4C management system can be executed while standing. The office could also be furnished with a desk behind which administration matters are attended to. A computer in the house is often preferred, but a greater distance between the herd and the computer will increase the risk of forgetting to enter data, with all its consequences. It is, therefore, advisable to install a second PC in the barn or to work with a PDA. An office with a view of the herd, milking robots, calving area and sick cow pens is always to be recommended. In this way, a watchful eye can be kept on the herd and a cow in heat can be detected. An office above the tank room at the side of the barn offers a good view of the entire barn and it is an efficient use of space.

Second PC
The following example will be familiar to many farmers. During one of the daily rounds through the barn a cow in
heat is observed and the farmer asks himself when she has last calved, whether she has been inseminated and when that took place? At such moments it is important to have that kind of management information quickly at hand. Sitting in front of the PC in the living room would not have been very convenient at that particular moment.

The farmer could have missed that cow in heat before he had realized it. The availability of a second PC in or near the barn will be of great service. The main computer is kept in a clean, dust-free environment. The second PC is in the vicinity of the herd so that the farmer does not have to take his boots off.

Other points for consideration during the layout of a barn

- One-way gates are a good solution when gates are necessary in the barn, but try to avoid installing them as much as possible.
- The tank room should always be kept clean and tidy; the walls, floor and ceiling must be easy to clean.
- A temporary flexible holding area has the advantage that ‘fetched’ cows are not hindered by more dominant animals when entering the robot.
- The maximum recommended amount of feed in the robot is 2.5 kg (5.5 lb) per cow per visit; experience learns that a maximum of 8 kg (17.6 lb) concentrate feed per cow per day should be dispensed.
- A computer in the barn – in an office above the barn or wherever – will make work easier and will reduce the risk of “forgetting”.
6 Existing barn and renovation

6.1 Conversion or construction?
Prior to executing a change in operational management – the switch to robotic milking and/or expansion of the farm – it is important to consider whether the current housing of the cows lives up to expectations and future requirements. Sometimes a few adaptations, such as the construction of an extension, the replacement of the cubicles, or raising the roof, could breathe new life into the building. In other situations, the preference will be for an entirely new building that meets all the requirements, also for the future. The Astronaut milking robot can be installed in an existing situation or in a new building. In addition, the milking robot can always be moved to another location later on, which will guarantee greater flexibility.

6.2 Installing a robot in an existing barn
A new robot is often installed in an existing barn. In that case, a number of adaptations are necessary to install the robot in the barn and to arrange the routing of the cows to the robot. In addition, it is important to consider to what extent the current barn can offer comfort and space to the cows.

The renovation of a barn is an option when:
- Renovation is much cheaper than building a new barn.
- The barn does not deviate too much from the required barn after renovation.
- There is room for future expansion or improvement of the existing barn.
Critical discussion points for renovation are:

A renovation plan: Make a renovation plan for the entire herd. Farmers often forget that an expansion of the barn area for dairy cows often necessitates expansion of the area where the young stock are housed, given the fact that more heifers are held for replacement. It is often apparent later on that the construction of a new building would have been better for the cows and that the existing building is perfect for the rearing of calves.

Decision list: Make a list of the decisions that have been made, for example with regard to the choice of cubicle bedding and barn layout. Check this list once all the decisions have been made and have a look at the effect the decisions have had on the entire operations management. The effect a decision has had on labour utilization, for example, is often overlooked. Adapt the list if necessary and use it during the renovation.

In the paragraphs below, the comfort of the cubicles, the quality of the feed fence and barn floor, and the ventilation possibilities are dealt with. By assessing these points in the existing barn, an overview is created of the points for improvement and thus the points in the barn that require adapting. Also, attention is paid to the opportunities for the appropriate routing of cows to the robot. Free cow traffic is an important condition in this respect.

6.3 Comfort cubicles

To determine how comfortable cows are in an existing barn, the farmer can conduct a number of tests. At a moment when it is relatively quite in the barn, count the number of cows that are standing, lying and eating. Compare the number of these animals to the number of cows that would be standing still in the field for no particular reason. Not many healthy cows in the field stand still without good reason.

The following is an example of the above test, which was conducted on a quiet winter morning in a barn with 70 cows. 10 cows were standing up eating, 2 were standing up and staring straight ahead of them for no apparent reason and 58 were lying down resting. How do these numbers relate to the animals in the farmer’s barn? This example shows a normal division of the cows over the activities eating, resting and lying down.

If a deviation is found after counting, it could mean that there is something wrong with the cow comfort. Try to find out exactly what is wrong. Cows have to make a number of decisions before they lie down. Take time to observe the lying down process. Are they hesitant, or afraid? Or are they confident? From a standing position to a lying position in the cubicle means that the cow has to go down on her knees. Could this be painful? Can they injure themselves when they lie down? By observing the lying down behaviour it can be assessed whether there is sufficient room and whether the cows are experiencing any difficulties. Pay attention to the physical condition of the cows. Swollen knees or bare heels should not occur. And how does the barrel of the cow look? Are any abscesses, swellings or bruises visible? Conducting these simple tests will give a clear picture of the comfort of the cubicles.

6.4 Quality of the feed fence

In order to take up as much roughage as possible on a daily basis, the cows must be able to eat comfortably. Besides the fact that there should always be sufficient good quality roughage available, the animals should be able to eat their feed calmly, in a good position at the feed fence. In older barns, the top bar of the feed fence is often too low and can cause irritation to the neck. Contusions, irritations and abscesses of the neck may be the result of regular jolting or prolonged pushing against a low bar. Lesions or pressure points on the shoulders may be due to a low feed alley or
that feed is not pushed up enough whereby the animals have to stretch too far. In assessing the feed fence and the feeding method, consideration should be given to feeding management.

At various moments of the day, have a look in the barn at how many cows are eating roughage and regularly check on rumen fill. Too little rumen fill may mean that the quality or quantity of the roughage provided is insufficient, but it can also mean that there are insufficient eating places available. Also pay specific attention to the rumen fill of low-ranking animals, such as cows and heifers that have recently calved.

6.5 Ventilation possibilities in the barn
Farmers are becoming increasingly aware of the importance of sufficient fresh air compared to the past. One of the most important parameters in monitoring adequate ventilation is the farmer’s own feeling about it. During the various seasons of the year, take time to consciously stand still in order to compare the climate in the barn to that of the climate outside. How does the climate in the barn feel? Is it cold? Is it warm? Is it a question of draught or natural ventilation? How is the humidity? Is there a strong smell of manure or ammonia? The air current in the barn can be detected through a smoke test.

It is also important to observe the behaviour of the cows. If there is a corner of the barn where the animals do not lie down, it can be an indication of draught or lack of fresh air. Cows searching for air vents may indicate a lack of fresh air. In many cases ventilation can be reasonably improved by enlarging the openings in the walls. For example, a wall could be removed to a height of one metre, or almost completely be replaced by windbreak netting. The installation of ventilation could also be a solution.

6.6 Assessing the barn floor
A barn floor wears out over the years though intensive use: the floor becomes less walkable through becoming too smooth or through sharp protrusions, and manure inadequately falls through the slats. Cows feel insecure on a floor that is too slippery and their progress is slow. In addition, they could slip during a confrontation with another cow, or the farmer, and they express little signs of heat, such as bulling. A slippery floor can easily be roughened or fitted with a top layer of rubber.

In the case of a slatted floor with split or sagging slats, the slats must be replaced immediately to minimize the risk of claw injuries. If desired, the slats can be immediately replaced with rideable slats to allow mechanical spreading in the future.

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**Signals that indicate the feed barrier is not of a sufficient quality:**

- The animals have to go down on their knees in order to eat.
- The cows rub their necks along the top bar, which causes irritation to the shoulder.
- The surface of the feed alley grazes if knuckles are scraped on the floor.
- Certain feeding places are avoided.

**The quality of a barn floor is adequate when:**

- The cows walk with confidence and with sufficiently large paces.
- The animals are well able to show signs of heat.
- Cows show comfort behaviour, such as licking themselves.
- The floor shows no irregularities or sharp protrusions.
- The manure can fall through the slats.
- The slats have not split, subsided or crumbled.
6.7 Routing to the robot

The most important aspect of integrating a milking robot in a barn is the creation of sufficient space to house it. For one robot a minimum space of 5 metres (16 foot) should be taken into account; with two robots the required space is a minimum of 7 metres (23 foot).

Furthermore, it is very important that there are sufficient intersections from the lying to the feeding area and vice versa to allow the animals to pass each other unhindered. For appropriate advice on the installation of a robot in an existing barn, please contact a Lely consultant.
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Detailed example of barn lay-out: the numbers refer to paragraphs in this chapter. Source: Lely Industries
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