HOUSING THE MODERN DAIRY COW

Introduction

The vast majority of dairy cows are housed for part, if not all, of the year. The housing provides shelter from adverse weather, prevents poaching of grazing areas and provides easier management and control of the dairy herd.

The modern dairy cow is now significantly larger than the animals which were milked 30 years ago when much of the existing cow accommodation was constructed. Where cows are housed for a significant period of their lactation, shortcomings in housing systems become more noticeable. This can create significant adverse effects on animal health, welfare and production. The problem is compounded by an increase in herd size without due account of the need to increase the housing facilities.

Climate change will also have an impact on dairy cow housing. A recently published DEFRA study examining the effects of climate change on UK Agriculture confirmed that the past decade in the UK has been the warmest for 300 years.

Warm winters have become more common, while warm summers have included record temperatures. By 2050, the study concludes the UK temperatures will increase by around 2°C.

Dairy cow housing needs to be designed, built and managed to take account of the changing requirements of the dairy cow and the changing climatic conditions.

It has been acknowledged by Defra that current design recommendations for cattle buildings fall short of the requirements of the modern cow. To address these concerns, the BS5502 part 40 (cattle) was updated as part of a previous welfare programme. The updated BS5502:2005 was published in October 2005.

Poor design can lead directly to a number of welfare problems – for example:

- Passageways being too small for the size of cow (leading to many of the injuries highlighted in the Reducing Dairy Injuries Campaign),

- Poor ventilation with the consequent affect on mastitis and respiratory diseases,

- Inadequate feed space and water trough size, location and numbers (which all influence the success or otherwise of production, growth rates, metabolic disorders, fertility, longevity).

This DEFRA funded campaign is designed to highlight some of the latest recommendations on the design of housing systems for the modern dairy cow.

Animal Welfare

The welfare of cattle should be assessed in the context of a framework described in the 1997 Farm Animal Welfare Council Report – Report on the Welfare of Dairy Cattle. The guidelines are described as the Five Freedoms. The Five Freedoms form a logical basis for assessing animal welfare within a husbandry system.
• Freedom from hunger and thirst – by ready access to fresh water and a diet to maintain full health and vigour.

• Freedom from discomfort – by providing an appropriate environment including shelter and a comfortable resting area.

• Freedom from pain, injury and disease – by prevention or rapid diagnosis and treatment.

• Freedom to express normal behaviour – by providing sufficient space, proper facilities and the company of other animals.

• Freedom from fear and distress – by ensuring conditions and treatment which avoid suffering.

All buildings and housing systems should be designed, constructed, maintained and managed to assist in the achievement of the Five Freedoms.

**Requirements for Housing**

Whether cows are housed in cubicles, straw yards or cow sheds, in order to maximise performance of the cows and to ensure satisfactory standards of welfare, the accommodation must provide for the cow’s most basic needs. As an absolute minimum, the housing must provide a comfortable, clean, well drained and dry lying area together with shelter from adverse weather. It must also allow the animal to move freely around without risk of injury. If the housing system does not provide for these basic needs then not only will both production and welfare be compromised but it is likely that you are also failing to comply with the welfare codes and the law relating to animal welfare.

The type of housing varies considerably throughout the country, with cubicles being very much in the ascendance. In parts of the UK they account for more than 90% of the housing. However, very few dairy holdings have only cubicles, there will nearly always be a straw (loose) yard.

There are advantages and disadvantages with both housing systems and it is therefore impossible to state categorically which is better for a modern dairy cow.

A brief comparison of cubicles and straw yards is illustrated in Table 1 (see over).

There has been considerable research undertaken which confirms that dairy cows housed on a straw yard system will typically suffer elevated levels of clinical mastitis over their counterparts housed in cubicles. The cows on straw yards will however, generally have fewer problems with their feet. However, the results are influenced by overstocking and inadequate facilities for the size of cow and herd. Where conditions are optimum the herd health and welfare appear similar in both systems. What is more important is the surface on which the animals lie.

The selection of a particular housing system is frequently driven by the availability and costs of local bedding materials and how these materials can be handled within the constraints of an existing waste system.
Table 1 – Comparison of existing cubicles and straw yards

<table>
<thead>
<tr>
<th>Cubicles</th>
<th>Straw Yards</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Advantages</strong></td>
<td><strong>Advantages</strong></td>
</tr>
<tr>
<td>Lower bedding requirement</td>
<td>Lower risk of lameness</td>
</tr>
<tr>
<td>Flexibility with bedding materials</td>
<td>Lower risk of damage to knees and hocks</td>
</tr>
<tr>
<td>Lower risk of environmental mastitis</td>
<td>Lower capital outlay</td>
</tr>
<tr>
<td>Higher stocking rate</td>
<td></td>
</tr>
<tr>
<td><strong>Disadvantages</strong></td>
<td><strong>Disadvantages</strong></td>
</tr>
<tr>
<td>Passageways contaminated with slurry</td>
<td>Lower stocking rate</td>
</tr>
<tr>
<td>Increased risk of lameness/leg damage</td>
<td>More bedding required</td>
</tr>
<tr>
<td></td>
<td>Increased risk of environmental mastitis</td>
</tr>
<tr>
<td></td>
<td>Loafing areas contaminated with slurry</td>
</tr>
</tbody>
</table>

The amount of bedding used within any system will vary between operators. Quoted figures should be considered as averages. Table 2 gives an indication of the average volume of bedding, which may be required in differing housing situations.

Table 2 – Bedding use in housing systems

<table>
<thead>
<tr>
<th></th>
<th>Daily use kg/cow/day</th>
<th>Total use(180 day winter) kg/cow/winter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Straw (bedded yard)</td>
<td>15</td>
<td>2700</td>
</tr>
<tr>
<td>Straw (unchopped) cubicle</td>
<td>7</td>
<td>1260</td>
</tr>
<tr>
<td>Straw (chopped) cubicle</td>
<td>5</td>
<td>900</td>
</tr>
<tr>
<td>Straw (chopped) mat</td>
<td>3</td>
<td>540</td>
</tr>
<tr>
<td>Sawdust</td>
<td>1</td>
<td>180</td>
</tr>
<tr>
<td>Sand</td>
<td>14</td>
<td>2520</td>
</tr>
</tbody>
</table>

Building Construction

The British Standard for Agricultural Buildings and Structures (BS5502-40:2005) has recently been revised. This document provides clear recommendations and advice for agricultural buildings, which are to be used for housing dairy cattle.

The capital cost of dairy cow housing will vary according to the scale of the building and the housing system selected. According to the latest figures from SAC Farm Buildings Costs Guide 2005, a simple kennel building will costs around £100/m² while a straw bedded yard will cost around £146/m². A purpose built cubicle building will cost around £179/m².
General purpose buildings are often the building of choice, with the expectation that they can be used for other enterprises at a later date. However, such buildings may compromise animal welfare and productivity. This is certainly true of the construction of the roof, often leading to inadequate ventilation. Compare this with designs abroad, such as in Holland, where buildings are designed for the stock in question and ventilation is all important.

**Comfort of the Cow**

Whether cows are housed in cubicles, kennels or a straw yard, the housing system must provide a comfortable lying surface. Cows at pasture will choose to lie down for around 11.0 hours each day and we need to try and achieve similar lying times when cattle are housed. As a general rule cows will only lie for around 60 minutes, after that time she becomes uncomfortable due to high pressure points on the parts of her body in contact with the ground. In fact close observation of cows shows that she will lie down and get up at least 10 times per day.

If the cow spends less time lying down, she is likely to spend more time standing in loafing areas or at the feed stance which can adversely affect foot health.

Maximising lying times should be a clear objective with any cow housing system.

**Cow Cleanliness**

The rate of new mastitis infection increases with the number of bacteria in contact with the teat end.

Numerous studies have confirmed the close association between cow and teat cleanliness and new mastitis infection rates. Mastitis infections are a significant economic and welfare problem. Added to this cost is the time spent cleaning teats of dirty cows before milking. Although teat preparation to optimise milk let down is essential, extensive teat preparation of dirty teats is relatively ineffective.

The design of the cubicle, the dimensions of the bed, level of management, choice of bedding materials, stocking rates and ventilation can all affect cow cleanliness.

Frequent scraping of access passages, loafing areas and feed areas helps ensure these areas remain clean and dry. This will reduce the amount of soiling transferred to the bedded surface.

Digital dermatitis is now a major problem on many UK dairy herds. The disease is often associated with prolonged contact with slurry containing the bacteria *Fusiformis nodosus*. Keeping the cow’s feet clean and dry, combined with regular foot-bathing, has been shown to be effective in controlling the infection.

The consistency of the slurry has a marked effect on the cleanliness and hygiene within a housing system. This is particularly noticeable in straw yards. As the consistency of the dung increases, it is easier for animals to remain clean. Loose dung is a sign of either inappropriate feeding or disease – it is a misconception that high yielding cows will produce loose dung.
Cows showing signs of heat on a straw yard can rapidly turn a clean, dry bed into a quagmire. As well as soiling the beds, bulling cows can be a major cause of trodden teats.

**Design Requirements**

Modern housing systems have been designed to make management of the dairy herd easier and less labour intensive. To ensure these systems do not compromise animal welfare or production, a number of basic design criteria must be considered.

**Straw Yards**

*Shape of the yard*

The distance from the bedded yard to the feed area should be as short and direct as possible. The distance from the feeding passage to the back wall of a straw yard should not exceed 10.0m. This minimises the risk of animals treading on each other as they exit the yard.

This, together with the fact that cows tend to prefer to lie along side the wall as a “security” measure, means that a rectangular yard is considered a better shape than a square yard.

*Bedded area space allowances*

The space allowance required for each cow will determine the stocking rate of the yard.

BS5502:2005 suggests minimum area allowances for dairy cattle in straw yards. This is illustrated in Table 3.

**Table 3 Minimum area allowances for dairy cattle housed in straw yards**

<table>
<thead>
<tr>
<th>Mass of animal (kg)</th>
<th>Bedded area (m²)</th>
<th>Loafing area (m²)</th>
<th>Total area / cow (m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>200</td>
<td>3.5</td>
<td>2.5</td>
<td>6.0</td>
</tr>
<tr>
<td>300</td>
<td>4.5</td>
<td>2.5</td>
<td>7.0</td>
</tr>
<tr>
<td>400</td>
<td>5.5</td>
<td>2.5</td>
<td>8.0</td>
</tr>
<tr>
<td>500</td>
<td>6.0</td>
<td>2.5</td>
<td>8.5</td>
</tr>
<tr>
<td>600</td>
<td>6.5</td>
<td>2.5</td>
<td>9.0</td>
</tr>
<tr>
<td>700</td>
<td>7.0</td>
<td>3.0</td>
<td>10.0</td>
</tr>
<tr>
<td>800</td>
<td>8.0</td>
<td>3.0</td>
<td>11.0</td>
</tr>
</tbody>
</table>

*Feed stance/loafing area*

Any housing system based on straw yards must provide a concrete area for loafing and feeding. This helps promote hoof wear and will prevent feet becoming overgrown.

If the loafing area also serves as a feeding passage, the minimum width of the feed passage should be 4.0m. This allows cows to feed at the manger, with other
animals moving around behind them. The loafing area should be scraped at least twice each day to reduce faecal soiling of the feet.

**Location of water troughs**

It should be impossible for a cow to drink from a trough while standing on the bedded area. When this happens, the surrounding bedded area rapidly becomes wet and dirty. Troughs can be located in the feed barrier or on the edge of the bedded yard (protected by a block wall) so cows can only drink from the concrete feed stance.

The trough should not protrude into the loafing area, as this will affect the ability to scrape the area completely.

**Access from the straw yards**

There should be un-restricted access from the straw yard to the feeding/loafing area. Narrow gateways or restrictions will lead to the development of soiled areas and a reduction in the available bedded area.

A step should be provided between the feeding/loafing area and the straw beds. This will help retain the straw and prevent slurry flowing onto the bedded area. A solid barrier also provides a straight edge to scrape against when cleaning out the loafing area. The height of the barrier will depend on the frequency in which the beds are cleaned out, but it is likely to be around 0.2m. The barrier height should not exceed 0.3m.

An essential element of an environmental mastitis control plan is the ability to keep the cows on their feet, on clean concrete, for a minimum of 30 minutes after milking. This can be achieved with tensioned wires, electric fences or frequent gates.

**Cubicles**

Cubicles must provide a clean comfortable lying space for cows. The cow must be able to enter and leave the cubicle easily and lie down and rise without interference or injury. Poorly designed cubicles and inappropriate management leads to problems such as cubicle rejection, wet and soiled cubicle beds and physical injury to cows.

The length of the cubicle needs to be adequate to allow the cow to rest comfortably and rise without injury. The position of cows when lying down and standing are controlled by brisket boards and headrails. A correctly located cow means that urine and dung fall into the scraped passage and not on to the cubicle base.

There needs to be sufficient distance between cubicle divisions to allow the cow to lie comfortably while ensuring she is unable to turn around. The cow should not come into contact with the cubicle partition in such a way that could cause injury, be it when she lies down or rises.

When a cow rises from a lying position, she lunges forward to transfer the weight from her hindquarters onto her front legs. To accommodate this transfer of weight, the cow thrusts her head forward. Studies suggest a rising cow requires 0.7 to 1.0m
of space in front of her to rise easily. If the forward lunging space is restricted, she will have difficulty in rising.

**Number of cubicles**

There should always be at least 5% more cubicles than cows within a management group.

When there are more cows than cubicles within a building, the building is overstocked. There are a number of significant issues with overstocking a cubicle building.

Firstly, the addition of every extra animal adds at least another 60 litres of slurry into the system each day. This extra slurry is distributed on the same surface area, which leads to an increase in hoof and cubicle bed soiling.

Secondly, a number of studies have reinforced the argument that overcrowding will decrease lying times in cubicles. Cows lower in the social hierarchy will forfeit their place to more dominant animals, leading to extended periods of standing and deterioration in foot health.

Thirdly, when a cubicle system is designed and built, the feed face per cow and available water troughs are calculated on a known number of cows. Increasing stocking rate above this level can lead to competition for feed and water.

The location of the cubicle within a building can affect occupancy. Cubicles closest to a feed passage will be occupied for more of the time than cubicles in the far corners of buildings. Cubicles at the end of rows will be occupied less than cubicles located in the centre of the building. This suggests that certain stalls, particularly those furthest from the feed stance or at the ends of rows are less desirable to cows.

**Number of rows of cubicles**

Cubicle buildings with a central feed passage are generally referred to as either two-row or three-row designs. A three-row design has three cubicle places feeding on a single feed place while a two-row design has two cubicle places feeding on a single feed place.

When both designs are considered, there is a reduction in passage surface area per cow of around 20% when a three-row system is compared with a two-row system. Providing 20% more passage surface area to distribute slurry in a two-row system means feet stay cleaner and the risk of bed soiling is reduced.

As described with straw yards, the cows need to be kept standing on clean concrete for 30 minutes after milking. Although this can be achieved with a three-row system, it requires the use of electric fences or other moveable barriers to prevent cows accessing the row of cubicles, which are adjacent to the feed stance.
Passage widths and layout

Passages and cross passages should be designed to ensure that there are no dead ends. A dominant animal can interact aggressively with an animal of lower social ranking wherever there are dead ends or narrow access points.

BS5502 recommends a minimum loafing area of 3.0m² per cow. To achieve this figure within the confines of a feed/sleep building, the width of the scrape passage between rows of cubicles should be a minimum of 3.0m.

Where a three-row cubicle system is built, with cows reversing out of the cubicles into the feed passage, the feed stance passage width should be 5.0m. When a two row system is built, the feed stance width can be reduced to 4.0m.

Cross passages should be installed at the end of every row of cubicles to remove dead ends. A cross passage should also be located every 20 cubicle places. The cross passages should be constructed to the same height as the surrounding cubicle beds to ease cleaning.

The cross passage should be a minimum of 2.4m wide (assuming that no water trough is installed). When a drinking trough is installed, the width should be increased to a minimum of 3.6m to allow cows to pass, while others drink.

Cubicle dimensions

The dimensions of a cubicle are dependent on the size of the cow. This is best estimated using body weight.

The body weight of an animal can be estimated by measuring the chest girth and the diagonal body length. This is demonstrated in Table 4.

Table 4 – Relationship between chest girth, diagonal body length and weight.

<table>
<thead>
<tr>
<th>Cow body weight (kg)</th>
<th>Chest girth (m)</th>
<th>Diagonal body length (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>375</td>
<td>1.68</td>
<td>1.36</td>
</tr>
<tr>
<td>425</td>
<td>1.75</td>
<td>1.41</td>
</tr>
<tr>
<td>475</td>
<td>1.81</td>
<td>1.46</td>
</tr>
<tr>
<td>525</td>
<td>1.87</td>
<td>1.50</td>
</tr>
<tr>
<td>575</td>
<td>1.93</td>
<td>1.54</td>
</tr>
<tr>
<td>625</td>
<td>1.98</td>
<td>1.58</td>
</tr>
<tr>
<td>675</td>
<td>2.04</td>
<td>1.62</td>
</tr>
<tr>
<td>725</td>
<td>2.09</td>
<td>1.65</td>
</tr>
<tr>
<td>775</td>
<td>2.14</td>
<td>1.68</td>
</tr>
<tr>
<td>825</td>
<td>2.18</td>
<td>1.72</td>
</tr>
</tbody>
</table>

Research has concluded that cubicle usage increases with increased cubicle size. However, the dimensions required for a cubicle will depend on the cubicle location (e.g. against an outside wall, open fronted facing a feed passage or head to head facing another cow).
Cubicle Length

The total length of the cubicle should provide body space, head space and lunging space.

Cubicles which are open fronted (either facing a feed passage or head to head) allow a cow to share space, either by placing her head in the opposite stall, in a head to head arrangement, or by utilising the extra space available in the feed passage.

Cubicles, built against an outside wall (or otherwise closed at the front) reduce lunging space. The length of these beds needs to be increased.

When rising naturally, a cow will lunge forward. If a closed front cubicle is too short, the cow may lunge to the side. Selecting a cubicle division, which allows this lunging action, can be helpful.

When a cow can lunge forward, she will lie straighter in the cubicle. Cows which are forced, by inadequate cubicle length, to lunge to the side will often lie at an angle in the cubicle which can result in increased soiling at the back of the bed.

BS5502 suggests minimum cubicle length dimensions. This is shown in Table 5.

Table 5 – BS5502 Guidelines on cubicle length

<table>
<thead>
<tr>
<th>Weight of cow (kg)</th>
<th>Total length of bed (m) (open front)</th>
<th>Total length of bed (m) (closed front)</th>
</tr>
</thead>
<tbody>
<tr>
<td>500</td>
<td>2.05</td>
<td>2.35</td>
</tr>
<tr>
<td>600</td>
<td>2.15</td>
<td>2.40</td>
</tr>
<tr>
<td>700</td>
<td>2.20</td>
<td>2.50</td>
</tr>
<tr>
<td>800</td>
<td>2.25</td>
<td>2.55</td>
</tr>
</tbody>
</table>

Some work recently published in the USA indicates that for the larger cow (>700kg) there are, in fact, additional benefits from a slight increase in bed length. These dimensions are shown in Table 6.

Table 6 – USA Guidelines on cubicle length

<table>
<thead>
<tr>
<th>Weight of cow (kg)</th>
<th>Total length of bed (m) (open front)</th>
<th>Total length of bed (m) (closed front)</th>
</tr>
</thead>
<tbody>
<tr>
<td>500</td>
<td>2.05</td>
<td>2.05</td>
</tr>
<tr>
<td>600</td>
<td>2.15</td>
<td>2.15</td>
</tr>
<tr>
<td>700</td>
<td>2.30</td>
<td>2.55</td>
</tr>
<tr>
<td>800</td>
<td>2.40</td>
<td>2.70</td>
</tr>
</tbody>
</table>

As the length of the bed increases, the length of the division should increase. To prevent cows walking along the back of the cubicles or reversing into the beds, there should be around 0.35m from the back of the division to the cubicle kerb.

Where cows stand up horse or dog fashion then cubicle length is likely to be too short.
Cubicle width

Cubicle width must allow the cow to rise and lie easily. But if the cubicle width is excessive, the cows will tend to lie at an angle in the stall. Smaller cows may try and lie backwards in the cubicle. The width of the cubicle will be determined in part by the choice of cubicle division. If the division fitted has a rear support leg, the partition should be installed with a clear distance between partitions of 1.2m.

With divisions that are space-sharing, such as the suspended cantilever type, the distance between divisions can be reduced. It is quite common to see divisions installed at 1.125m centres.

Division design

There are many types of cubicle division on the market. Whatever the type they must provide the cow with maximum comfort, provide security/protection, prevent injury and ensure that she is correctly positioned, both standing and lying.

Many of the traditional division designs have sections of the division which can restrict animal movement. Lower rails can lead to cows becoming trapped and many partitions with a rear support legs, cause damage to cows hocks’ and pelvis’.

When different cubicle divisions were compared, there was noticeable difference in occupancy levels. This is demonstrated in Table 7.

Table 7 – Occupancy rates for a range of partition designs.

<table>
<thead>
<tr>
<th>Partition Design</th>
<th>% Occupancy/cubicle (lying)</th>
<th>% Occupancy/cubicle (lying and standing)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Newton Rigg</td>
<td>30</td>
<td>43</td>
</tr>
<tr>
<td>Dorsdun</td>
<td>31</td>
<td>46</td>
</tr>
<tr>
<td>Dutch Comfort</td>
<td>33</td>
<td>50</td>
</tr>
<tr>
<td>Dutch Cantilever</td>
<td>39</td>
<td>64</td>
</tr>
<tr>
<td>Super Dutch Comfort</td>
<td>51</td>
<td>71</td>
</tr>
</tbody>
</table>

The main benefit of the suspended cantilever division is that both height and width spacing can be altered at any time. This provides flexibility where cow size changes over time but also allows management decisions to be made such as housing all heifers as one group.

Brisket Board and Head Rail

The purpose of the brisket board is to position the cow correctly when she is lying down. When the brisket board is correctly located, the cow will dung into the scrape passage.

The board should be angled towards the front of the cubicle to allow for the natural shape of the cow’s neck. The distance from the rear edge of the brisket board to the rear kerb should be 1.6–1.8m. The brisket board should not be more than 0.1m in height. If too far forward then the cow will often have difficulty rising and the base of the cubicle also becomes more soiled.
The purpose of the head rail is to position the cow when she enters the cubicle, before she lies down. If it is too far forward on the partition, when the cow is standing with four feet on the cubicle, she can soil the back of the bed. If it is too close to the kerb, it will limit the occupancy of the cubicle and cause the cow to stand “2 feet in and 2 feet out” with the detriment to rear legs and feet.

The height of the head rail should be between 1.2–1.25m above the base of the cubicle bed, which is commonly around 200 mm below average withers height. The head rail should be 1.6–1.8m from the cubicle kerb. Small changes can have a large impact on occupancy, cow injury and bed cleanliness.

Another suitable check measurement is the diagonal distance between the headrail and the edge of the kerbstone/heelstone. This dimension should be in the order of 2.1m (7 ft).

*Kerbstone/Heelstone*

The height of the kerbstone should be between 0.15–0.2m. The final height of the kerb will be dictated by the method of slurry removal.

Long scrape passages may require a slightly higher kerb to prevent slurry contaminating the back of the beds. A slatted scrape passage will allow the kerb to be reduced in height. The kerb height should not be reduced below 0.15m, as this can encourage some cows to lie partly in and partly out of the cubicle.

If mats or mattresses are fitted, their height should be considered in the kerb depth calculation.

*Slope*

Cows prefer to lie facing uphill so cubicle beds should be installed with a slight fall from the front to the rear. The fall will also help drain any liquids (e.g. milk and urine) which could otherwise contaminate the bed.

A consistent fall of 2 – 3% along the length of the cubicle bed is satisfactory. This is less than the previous recommendation. Formerly, the recommendation was to install a 3% slope, although this has now been shown to cause problems with bedding retention.

*Cubicle Lying Surface*

The surface of the cubicle has many roles to fill. It must be:

- comfortable to the cow and encourage high occupancy;
- prevent hock damage and other injuries;
- easy to keep clean and be durable;
- cost effective to install.

The aim is to provide a combination of the correct cubicle dimensions and a comfortable bedding surface to encourage cows to optimise their lying time which will have a direct influence on the condition of their feet, the level of lameness and will increase rumination.
There are numerous types of cubicle surface available. The general findings from research work is that the softer the lying surface the more acceptable it will be to the cow and the lower the level of lameness. Many concrete cubicles, which were originally bedded with straw, have installed an artificial lying surface (mat or mattress) to reduce hock damage and to try and increase occupancy.

An MDC funded study in 1997, examined cow comfort on cubicle beds. The study compared the impact absorbing properties of a rubber crumb mattress with an EVA (ethylene vinyl acetate) mat. The study concluded that a new rubber crumb mattress provided a softer bed than a new EVA mat. However, after four years of use, the EVA mat had maintained its original softness while the rubber crumb mattress had become harder.

Whether mats or mattresses are installed, a layer of bedding is required. The role of this bedding is to absorb moisture and help keep the cows clean.

Sand bedded cubicles are becoming very popular in the UK. The claimed benefits include improved foot health, reduction in mastitis and less damage to knees and hocks. However, the uptake of sand as a bedding medium is limited by the adverse effects that sand can have on waste handling systems.

Researchers at the University of Kentucky looked at cow preference for different cubicle bases over a three year period. They compared sixteen different surfaces including concrete with chopped straw, sand, waterbeds, rubber filled mattresses and rubber mats.

Sand and rubber filled mattresses consistently showed the highest occupancy while concrete and rubber mats consistently showed the lowest occupancy. The results can be seen in Table 8.

**Table 8 – Cow preference for different stall bases**

<table>
<thead>
<tr>
<th>Cubicle base</th>
<th>% stalls occupied</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rubber filled mattress</td>
<td>89</td>
</tr>
<tr>
<td>Sand</td>
<td>79</td>
</tr>
<tr>
<td>Mat</td>
<td>65</td>
</tr>
<tr>
<td>Concrete</td>
<td>39</td>
</tr>
</tbody>
</table>

One of the mattresses consistently ranked higher for occupancy than the other mattresses tested. This suggests that not all mattresses are equally attractive to cows and that general statements about ‘mattress’ performance may be misleading.

Various studies in the USA tend to indicate that cows prefer sand to mattresses although there was no affect on milk production. It could be argued from the findings that culling rates were less on sand than mattresses.

**Cow Flow**

There is a social hierarchy or ‘pecking order’ within all dairy herds. A thorough understanding of the implications of this hierarchy can improve the design of a housing system. When a new animal is introduced into a herd, she will meet other
animals, who already have an established position within the herd hierarchy. As a consequence of this interaction, the cow will establish herself in the pecking order. Some animals will be classed as dominant while other will be considered to be subordinate.

The housing system has to be designed to allow subordinate animals to move away from dominant animals without conflict. Cubicle passageways which end in a dead end mean that to escape a dominant animal a subordinate animal must walk past her. Therefore to allow a subordinate cow to avoid aggressive interaction all passageways must provide at least two escape routes.

For this reason and to optimise feed intake all cubicles should have a cross passage every 20 cubicles to allow cows’ access to the feed area.

Floor Surfaces

Floors should be designed and maintained so cows have the confidence that they can move around buildings without slipping or falling, particularly when the floor is covered in slurry.

Poorly designed, constructed and maintained concrete floors can cause considerable sole and hoof wall injury as well as injury from slipping and falling.

All concrete surfaces require some form of surface treatment to improve traction and the drier the surface the better the foot health.

For new concrete, studies at the Farm Buildings Centre in the 1970’ and 80’s and incorporated into BS5502 suggest that to provide maximum skid resistance for cattle walking in all directions a hexagonal pattern should be formed. The hexagon should have sides of 46mm and the groove should be 10mm wide and 6–10mm deep.

In access passages with known cow traffic direction, parallel grooves can be formed in the concrete. The grooves should be placed at right angles to the movement of the cattle. The grooves should be placed 40mm between centres and the groove should be around 10mm wide and 6-10mm deep to prevent slurry accumulation.

Parallel grooves are preferable, as squares and diamonds have been found to provide an increase in the number of pressure points on the cow’s feet, without any benefit in slip resistance.

However, when the direction of movement is more random, such as turning areas, then a pattern of squares or diamonds can be considered. The grooves should consist of a regular pattern with 40mm sides separated by 10mm wide grooves. Again the grooves should be 6–10mm deep.

Many new cubicle systems install automatic slurry scrapers. Practical experience suggests that irrespective of the frequency of operation, unless scraped runs are kept shorter than 25m, there is likely to be a build up of slurry in front of the scraper blade. This impacts negatively on foot health and can increase bed soiling.

Some farms are fitting rubber mats on scraped passages and feed stances to improve underfoot conditions for the cows. A study in the USA compared rubber
mats in the scrape passages with grooved concrete flooring. This study was unable to demonstrate any significant difference in several indices of lameness between the two floor surfaces.

When researchers in Germany looked at rubber mats on scraping passages, they compared a standard slatted scrape passage (40mm slots) with a rubber coated slatted scrape passage. They demonstrated that bruising on the sole of the hoof was reduced on the rubber coated floor and there was a significant reduction in lesions of the hoof wall caused by slippage.

Research has shown that, contrary to previous recommendations and practice, scraped floors should have a slight fall as this prevents slurry ponding, which has a marked effect on lameness. Not only do wet floors increase the risk of transmission of the bacteria that are associated with digital dermatitis they can also reduce hoof hardness and increases the susceptibility to wear and damage.

The floor should be installed with a fall of around 2.0% (1:50) to assist drainage.

**Feed Management**

*Feed System design*

The majority of cows are now fed at a trough, a feed trailer or a ring feeder, with self-feed silage becoming far less common.

In terms of food safety, quality assurance schemes and farm biosecurity it is not advisable for tractors, feeder wagons and other machinery to drive through or across fouled areas, e.g. the feed passage where cows stand. Therefore if planning a new feeding system due account must be taken of future expectations.

A drive through feed passage should be a minimum of 4.6m wide, but does add significantly to the overall size and cost of a building. Besides the biosecurity advantage such a design allows animals to be fed when it is most convenient for farm staff, rather than limiting feeding to milking times when the feed stance is clear, and allows the feed to be topped up as necessary.

Perimeter feeding will normally provide biosecurity and flexibility of feeding time benefits but also saves on building costs as the feed stance is positioned on the outside of the building and cows feed through the side walls either onto a raised feed table or into a trough. A canopy is provided over the feed to minimise the effects of inclement weather.

The drawback of an open feed yard is that the animals have to leave the protection of their housing. This can severely hamper feed intake when weather is poor and hence productivity and obviously compromises animal welfare. It also increase the volume of dirty water which has to be land spread. It is therefore likely that we will see a move away from open feed yards.

*Space allowance for feeding*

Correct design of the barriers and mangers should provide access to a large volume of feed, prevent bullying and feed wastage while ensuring a safe, non-injurious
environment for the cows. Although feed may be ad lib and available 24 hours per day, as with TMR, it has to be recognised that there are peak periods for feeding during the day. These are usually immediately after the fresh feed is dispensed and following a milking. If there is competition for feed space during this period, subordinate cows will give way to dominant animals and modify their feeding behaviour.

The dimensions behind the feed barrier are critical to ensure that animals can pass behind those already feeding without disturbing them. In a two-row cubicle system, where the animals in the second row can lunge into the feed passage, aim for a width of 4m. With a three-row system, with animals backing out of cubicles into the feeding passage, the width should be increased to a minimum of 5m.

The management of the feeding system is important to ensure that cows maximise feed intakes. The feed barriers or mangers need to be designed and maintained to ensure that cows can easily access feed with no risk of damage or injury.

To reduce wastage and prevent slurry contaminating the feed, the bottom of the feed trough should be raised above the cow standings by 100mm. This also reduces weight transfer onto the front feet. The surface should be smooth to encourage intakes and ease cleaning. Over time concrete, in particular, becomes rough due to the acidity of the silage and this adversely affects eating behaviour as the cow’s tongue is exposed to a rough surface.

The amount of feed face per animal will depend on the weight of the animal and the competition for feed. If all animals are expected to eat simultaneously, the feed face required per cow, as described by BS5502:2005, is shown in Table 10.

**Table 10 – Feed face required for cattle eating simultaneously.**

<table>
<thead>
<tr>
<th>Mass of animal (Kg)</th>
<th>Width of feed face (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>200</td>
<td>0.40</td>
</tr>
<tr>
<td>300</td>
<td>0.50</td>
</tr>
<tr>
<td>400</td>
<td>0.55</td>
</tr>
<tr>
<td>500</td>
<td>0.60</td>
</tr>
<tr>
<td>600</td>
<td>0.67</td>
</tr>
<tr>
<td>700</td>
<td>0.70</td>
</tr>
<tr>
<td>&gt;800</td>
<td>0.75</td>
</tr>
</tbody>
</table>

Although BS5502 suggests that when feed is available 24hrs per day the feed face allowance per cow can be reduced by 75%, even with ad lib access to feed there are periods in the day when demand for feed is high. Animals lower in the pecking order may be driven away from the feed face. Aggressive interactions between cows are also reduced when the feed space per cow is high.

**Feed barrier design**

It is impossible to be prescriptive when describing dimensions for any feed barrier, as there will always be some variation in stature between herds.
The most popular barrier type is a post and rail barrier. It is relatively inexpensive to construct but provides no restriction to sideways movement and can encourage bullying when feed face per cow is restricted. The post and rail also permits some adjustment in dimensions to suit individual herd circumstances.

The brisket board should be around 500mm above the feed stance and should be rounded to avoid rough edges, which may injure the animal.

The rail should be positioned around 700mm above the top of the brisket board although this should be mounted to allow some adjustment. The top of the cow’s neck should barely touch the rail when she reaches forward to feed. The rail should be mounted on the feed side of the stanchion to allow the cow maximum reach with minimum contact with the rail.

There are several alternatives to the simple post and rail fence. The self locking yolks are very popular in Europe and the USA where they are used as an alternative to a handling facility. They provide an opportunity to keep cows on their feet after milking, reduce bullying when cows are feeding and allow routine tasks such as PD (pregnancy diagnosis) and AI.

Probably the most common type in the UK are the feed barriers with vertical or diagonal rails, which does prevent some bullying of subordinate cows. An improvement on the tomb stone feed barrier is the inclined dovetail feeding barrier. This was designed with cow comfort and reduced injuries in mind.

**Drinking Water Requirements**

Fresh clean water should be available at all times.

The water requirement of a cow will depend on a variety of factors, including milk yield, dry matter content of the feed, stage of lactation and ambient temperature. A high yielding cow can require up to 150 litres of water/day. A rule of thumb is that cows need 5 litres of water for every litre of milk they produce.

Peak drinking water demands coincide with the completion of milking and around sunset. Up to 50% of the cows daily requirement can be consumed during these times. It is important to recognise these peak periods and provide adequate trough capacity, ensuring that water flow rates are capable of supplying the peaks of demand.

Where water pressure is low, booster pumps or extra covered storage tanks that can fill during off peak periods, may be used. Where water pressure is adequate poor flow rates may be improved by using a larger supply pipe. Doubling the diameter of this pipe can increase the flow to the trough by up to 6 times.

Many troughs are fitted with the wrong pattern of ball valve and these should be replaced where necessary. Ball valves conforming to British Standards have interchangeable orifices and floats and it is important to use the right combination of these for each trough.

The orifice should be selected to pass the required flow at the working head available on the ball valve and then a float of suitable diameter chosen to close the
valve against the maximum static pressure on the trough. The following table shows how the orifice size affects the flow through the valve under a working head of 3m.

<table>
<thead>
<tr>
<th>Diameter of orifice (inches)</th>
<th>Flow (litres/second)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/8</td>
<td>0.03</td>
</tr>
<tr>
<td>3/16</td>
<td>0.06</td>
</tr>
<tr>
<td>1/4</td>
<td>0.1</td>
</tr>
<tr>
<td>3/8</td>
<td>0.24</td>
</tr>
</tbody>
</table>

For most herds the objective should be to provide a flow rate to the trough of a minimum 10 litres/minute.

Because dairy cows are sociable in their behaviour, it is important that there is adequate trough space to allow at least 10% of the herd to drink at anytime. A single animal drinking will require around 700mm of trough space.

Another rule of thumb is that the surface area of the trough should be 1m² for every 60 cows in the group.

The water trough should be located at the correct height for the cow. The edge of the trough should be 850mm from the floor the cow stands on. The water level should be 50–100mm below the edge of the trough to minimise splashing.

The provision of fresh, clean water is important to maximise intakes. A high turnover of water through a trough will improve water quality. Smaller troughs, which see a greater number of water changes, are preferable to large troughs where water movement is slow. Tipping troughs or installation of large bore drain holes (50–75mm) all ease the task of keeping water clean.

Troughs should be located so that cows on bedded yards can only drink when they are standing on the feed/loafing yard. In a cubicle based system, the drinking troughs should be sited on the walk through passages between rows of cows. The passage should be at least 3.6m wide to allow two cows to pass behind a group of animals drinking. A barrier must be provided between the water trough and adjacent cubicle to prevent cows having access. Not only will this increase the risk to mastitis (due to a wet cubicle base), it may also reduce the number of cubicles available for parts of the day the base will also become wet.

Building Ventilation

Natural Ventilation

Natural ventilation is the most efficient and least expensive system for providing an optimum environment within a building. The objective of the ventilation system must be to provide a continuous stream of fresh air to every housed animal at all times of the day or night. Buildings will naturally ventilate best when they are sited at right angles to the prevailing wind direction. Although in practical terms in the UK, the occurrence of the prevailing wind is only slightly higher than that from the other directions.

To ensure adequate ventilation, it is important that the building is designed to:
• Remove excess heat;
• Remove excess water vapour;
• Remove micro-organisms, dust and gases;
• Provide a uniform distribution of air;
• Provide correct air speed for stock.

In the UK, wind speed is above 1m/sec for more than 95% of the time. This means that for the majority of time, there is sufficient generating force to provide the necessary air changes within a correctly designed building by natural ventilation. For the remaining time, the building relies on the stack effect to replace foul air with fresh air.

Heat produced by the livestock naturally rises. If it is unable to escape from the building at the highest point (at the ridge), it will condense and remain within the building. This will raise the humidity within the building. As the air cools, it will fall back onto the bedding, increasing the moisture content and creating a suitable environment for bacteria to flourish.

If the warm air is able to exhaust from the ridge of the building, this draws fresh air into the building through the side inlets. This air change ensures the stack effect is maintained.

The pitch of the roof can influence how well the stack effect is established but selecting the pitch of a roof, particularly with a span building, will always be a compromise between ventilation and overall ridge height. Roofs are normally pitched around 12.5%.

It is essential that there are adequate outlets in the ridge of the building. An open ridge is generally between 0.3–0.4m wide and should be unrestricted. As a useful rule of thumb, there should be 5cm of ridge opening for every 3.0m of building width.

Although cranked open ridges are still commonly fitted, they only offer around 20% of the required outlet.

Spaced roofs (where the roof sheets are inverted and fitted with a space of around 10 mm between each adjacent side sheet) can be very useful, particularly if summer housing is being considered. With the emergence of multi-span dairy units, spaced roofs become a necessity. It should be remembered that a spaced roof will reduce the flexibility of the building, if it was to be used without animals.

There are an increasing number of farms where curtain sides to the cubicle building are being installed, which allows the amount of air, admitted through the inlets, to be varied according to prevailing weather conditions. These curtains can be lifted and raised manually or automatically and provide greater environmental control.

Consideration needs to be given to the prevailing wind direction when considering sidewall curtains. If there is insufficient weather protection, rain will drive into the building and result in wet cubicle beds. If sidewall curtains are to be considered, a revised cubicle layout with an outside loafing/scraping passage will protect the rear of the cubicle beds. Remember, cows do not like draughts.
The design of a successful natural ventilation system is complex and requires account to be taken of the span of the building, the location of the building relative to other buildings or obstructions (buildings and trees disrupt airflows for a distance of 5–10 times their height), the pitch of the roof, the stocking rate, mass of each animal and the bedding system.

BS5502, suggests optimal environmental conditions for dairy cattle. The conditions are described in Table 12. The ventilation rate describes the airflow required to change the volume of air within a building 10 times each hour and can be calculated by either estimating cow numbers or calculating building volume.

### Table 12 – Optimum environmental conditions for cattle

<table>
<thead>
<tr>
<th>Temp range (°C)</th>
<th>Maximum air speed at stock level (m/sec)</th>
<th>Ventilation rate /kg (m³/hr/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adult Dairy Cow</td>
<td>3 - 25</td>
<td>0.25</td>
</tr>
</tbody>
</table>

For a mature 750kg dairy cow, the building should provide a ventilation rate of 143 m³/hr in the winter and 300 m³/hr during the summer months. For a 90 cow feed/sleep cubicle building, the natural ventilation must provide 27,000 m³ of air each hour in the summer.

Using the volume calculation, the same building will contain around 2,640 m³ of air space. To ensure a satisfactory environment, this air space must be changed 10 times every hour, which equates to 26,400 m³ of air each hour.

This must be provided by adequate inlet and outlet ventilation.

**Mechanical Ventilation**

Some farms where cows are housed during the summer months have installed fans to assist air movement. There are two main types of fan available for assisting the ventilation of cattle buildings. These are:

- High Volume Low Speed Fans (HVLS);
- High Speed Fans (HS).

The HVLS fans are large fans (between 4.8–7.5m in diameter) which revolve slowly and move large columns of air at a relatively low velocity (2.0 km/hr). A 6.0m fan will typically move around 3,500m³/min of air.

A HS fan is more compact (less than 1.0m diameter) and operates at a higher speed. Each HS fan can typically move around 600m³/min of air. To move the same volume of air as an HVLS fan, six HS fans are required. Most HVLS fans are operated by a 0.75kW motor and research at the University of Kentucky has suggested that when HVLS fans are compared with HS fans, the same volume of air can be moved for around 30% of the energy cost. They have the added advantage of providing a more even air distribution within a building, preventing pockets of still and/or stale air which could be responsible for respiratory problems, especially in younger animals.
There are relatively few buildings, which cannot be made to ventilate naturally if they are designed carefully, or remedial works undertaken. The decision to resort to assisted ventilation, with the resulting running costs and maintenance should not be taken lightly. In addition, where mechanical ventilation is essential then fail safe systems and alarms are a necessity.

Heat Stress

Dairy cows are homeothermic animals and need to maintain a constant body temperature around 38º C. The body temperature can be affected by air temperature, radiant temperature, wind speed and relative humidity.

When an animal becomes heat stressed, her feed intake and milk yield will decline and milk composition will be affected. There will be a reduction in fertility, an increase in embryonic loss or a reduction in the weight of the calf at birth. There is often an increase in cases of clinical mastitis in heat stressed animals.

However, before this damage has been done there are more immediate signs that a cow may be heat stressed. Her respiration rate (panting) increases as does her water intake. A quick check of her rectal temperature will also be a good indicator (it increases). She will also change her eating behaviour, consuming readily digestible feed such as concentrates but leaving roughages. The latter have to be fermented in the rumen, creating heat.

Air temperature and radiant temperature directly influences the heat exchange ability of the animal. As wind speed increases, so does the amount of heat transfer from the surface of the cow. Increasing airflow over a cow has a dramatic effect on evaporative heat loss from the skin. Airflows as low as 10 km/hr (2.8 m/sec) can reduce respiration rates in heat stressed animals by as much as 50%.

Relative humidity can be a problem in either the summer or the winter. In winter, it can make the animals coats wet which reduces their insulating properties. In summer, it reduces evaporation and limits heat loss.

A number of researchers have suggested that for a lactating dairy cow, there is a band of temperature at which she is most comfortable. This comfort zone or Thermoneutral Zone is between -5º C (lower critical temperature) and +25º C (upper critical temperature). The objective of any dairy housing system must be to maintain this comfort zone, irrespective of season. At temperatures below the lower critical temperature (LCT) the cow will increase her dry matter intake to keep warm or convert feed to heat rather than produce milk. At temperatures above the upper critical temperature (UCT), cows will sweat in an attempt to dispel the excess heat and the cow will become heat stressed. When the relative humidity increases, the UCT will fall and animals will become heat stressed more quickly. As cows sweat at only 10% of the human rate they are much more susceptible to heat stress.

As the ambient temperature increases above the UCT, milk yields can fall by as much as 20%. There is evidence that heat stress is most marked when it comes in short periods with no time for the cow to adapt to the rising temperatures.
When ambient temperatures exceed 25º C, the cow begins to become heat stressed. As the relative humidity increases, the temperature at which she becomes stressed falls. The Temperature–Humidity index (THI) is an indicator used in the USA to assess heat stress. When the THI exceeds 72, the animal is considered to be heat stressed.

This is demonstrated in Table 13.

**Table 13 – THI Index**

<table>
<thead>
<tr>
<th>Temp °C</th>
<th>RH %</th>
<th>0</th>
<th>20</th>
<th>40</th>
<th>60</th>
<th>80</th>
<th>100</th>
</tr>
</thead>
<tbody>
<tr>
<td>22</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>72</td>
<td></td>
</tr>
<tr>
<td>24</td>
<td></td>
<td></td>
<td>72</td>
<td></td>
<td>73</td>
<td>75</td>
<td></td>
</tr>
<tr>
<td>26</td>
<td></td>
<td></td>
<td>72</td>
<td></td>
<td>74</td>
<td>77</td>
<td>79</td>
</tr>
<tr>
<td>28</td>
<td></td>
<td></td>
<td>72</td>
<td>74</td>
<td>78</td>
<td>82</td>
<td>84</td>
</tr>
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<td></td>
<td></td>
<td></td>
<td>74</td>
<td>77</td>
<td>80</td>
<td>83</td>
</tr>
<tr>
<td>32</td>
<td></td>
<td></td>
<td>72</td>
<td>76</td>
<td>79</td>
<td>83</td>
<td>86</td>
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<tr>
<td>34</td>
<td></td>
<td></td>
<td>74</td>
<td>78</td>
<td>82</td>
<td>86</td>
<td>90</td>
</tr>
<tr>
<td>36</td>
<td></td>
<td></td>
<td>76</td>
<td>80</td>
<td>85</td>
<td>90</td>
<td>94</td>
</tr>
<tr>
<td>38</td>
<td></td>
<td></td>
<td>78</td>
<td>83</td>
<td>87</td>
<td>92</td>
<td>97</td>
</tr>
</tbody>
</table>

The THI level of 72 is reached and the cow becomes stressed with temperatures as low as 22º C when the relative humidity is high (90%). As the humidity falls, the temperature at which the cow becomes stressed rises. When humidity is only 10%, the ambient temperature can be 29.4º C before the cow becomes stressed.

When the THI exceeds 80, the cow is considered to be severely stressed. When the THI exceeds 100, animals will die.

The installation of fans, combined with spraying water onto cows can also dramatically reduce the effects of heat stress.

A study in the USA suggested that when ambient temperatures reached 27º C, the addition of fans and sprinklers in the collecting yard reduced the cow body temperatures by 1.7º C. This increased milk yields by 0.79kg/day over cows with no access to fans or sprinklers.

Application of water to cows around the bedded area has implications for the dryness of the beds, the relative humidity of the building and ultimately mastitis levels. Water can be applied more easily within the collecting yard while cows wait for milking. When cows are closely confined in the collecting yard, ambient temperatures can rise rapidly.

There is evidence of considerable benefit from providing spray cooling and assisted airflow in the tight confines of the collecting and dispersal yards.

Although heat stress is often considered to be a summer problem, cows housed in the winter can become heat stressed, partly because of the reducing effect that humidity has on the UCT. In addition the temperature of a fully stocked building can be up to 10 ºC higher than the outside ambient temperature. Therefore with a RH of around 55% depressing the UCT by around 8ºC, i.e. to around 17ºC and with the
average temperature in the West Country during the winter being 8-10ºC, it is quite feasible for many herds to be suffering as a consequence.

**Roof Lights**

Sunlight flows through roof lights and can cause a significant increase in ambient temperatures inside a building. This creates a conflict between maximum amounts of natural light to ease photoperiod management and restricting roof light space to reduce temperatures in the summer months when cows are housed. The radiant heat load has been measured at 850 W/m² in collection yards with un-insulated roofs, which in effect reduces the UCT by around 5ºC. Consideration should be given to insulating collection yard roofs and those of the housing area when cows are kept indoors throughout the year.

There is a long standing recommendation that at least 10% of the roof area should be fitted as rooflights. Some sheds are being constructed with up to 20% rooflights. Although the environment within the shed is extremely light and pleasant at this level of natural lighting, it can create significant problems with the ingress of solar radiation.

**Light for lactating cows**

A dairy building is normally lit using a combination of natural light and artificial light. Natural light will enter the building through ventilating side cladding, doors and roof lights.

Artificial light is generally considered to fulfil two roles. Firstly to provide a low level of background lighting (maximum of 20 lux) to allow animals to move confidently around the building without risk of injury and secondly to provide a higher intensity of light (300 lux) for animal inspection and movement of machinery.

Artificially increasing day length, combined with bolstering natural levels of light within a building, have shown to be of benefit to dairy cows. Work undertaken at Bangor University demonstrated a 6% yield increase when cows were subjected to longer light periods with more intense light. Similar work in the USA has shown yield increases as high as 16%.

A review by the Farm Electric Centre considers a paper from Michigan State University which concludes that cows should be exposed to 16–18 hours of light (>200 lux) each day to achieve the benefits of long day photoperiod. The length of exposure to the light is important, as the benefits do not emerge until the cow has been exposed to 14–16 hours of light. This level of light is lower than that recommended for other areas of a dairy complex. The advisory light levels are illustrated in Table 14.

**Table 14 – Advisory light levels in cattle buildings**

<table>
<thead>
<tr>
<th>Task / Location</th>
<th>Illumination (lux)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Animal Inspection</td>
<td>300</td>
</tr>
<tr>
<td>Sick Pen</td>
<td>50</td>
</tr>
<tr>
<td>Dairy cattle building</td>
<td>200</td>
</tr>
<tr>
<td>Cattle building</td>
<td>20</td>
</tr>
</tbody>
</table>
These light levels can be equated to other situations to get an indication of levels required. This is demonstrated in Table 15.

**Table 15 – Actual light levels**

<table>
<thead>
<tr>
<th>Task / Location</th>
<th>Illumination (lux)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inadequate light to read</td>
<td>20</td>
</tr>
<tr>
<td>Bedroom</td>
<td>50</td>
</tr>
<tr>
<td>Living room</td>
<td>100</td>
</tr>
<tr>
<td>Kitchen</td>
<td>500</td>
</tr>
<tr>
<td>Office</td>
<td>500 - 700</td>
</tr>
</tbody>
</table>

The increase in yield noted with 200 lux for more than 16 hours each day is not immediate and the response will occur gradually over a number of weeks.

When consideration is given to extending the photoperiod, it is important to realise that during the winter months, natural light within a building is likely to only exceed 200 lux for around 8 hours and supplemental light will be required for the remaining 8 hours. Although there are benefits to artificially increasing day length, cattle also need a period of darkness, with a minimum of 6 hours recommended. Within the building some low-level lighting is required to mimic “natural night light” to enable cattle to move around. This should be a maximum of 20 lux.

The lighting period should be centred on the natural daylight cycle overlapping natural and artificial light as much as possible. The supplemental lighting should take account of the time of the day when access to the cows is required whilst taking maximum advantage of off-peak electricity.

**Light for dry cows**

A recent study in the USA suggested there were benefits to be obtained from manipulating daylight length in dry cows. This study demonstrated that dry animals who were subjected to a photoperiod which included 8 hrs daylight (>200 lux) and 16 hours of darkness (20 lux), produced 3.2kg/day more milk than dry cows subjected to a more typical 8 hours darkness and 16 hours daylight.

This practice is significantly easier to achieve during the winter months although dry animals housed in early spring and autumn may also benefit.

**Slurry Management**

Slurry will be removed from a housing system either by tractor scraping or by some form of automatic system. The most commonly seen automatic systems are automatic scrapers although there are a number of farms installing flush washing systems.

As well as tying up labour, tractor scraping can only be carried out while the cows are away from the housing system. When the scraping passages are long, unless frequent passes are taken, there will be considerable soiling on the back of the cubicle bed.
Automatic scrapers provide greater flexibility and can be operated more frequently. Unfortunately they are often associated with faecal soiling on cows legs and backs as well as an increase in levels of digital dermatitis.

Irrespective of frequency of operation, automatic scrapers are associated with a bow wave of slurry, which proceeds the scraper blade. The bow wave effect can be reduced by installing a slatted cross passage every 25m.

Flood washing cubicle passages or ‘flushing’ has recently received some interest from the farming press. The developers of flood washing systems claim:

- Labour saving compared to tractor scraping;
- More frequent cleaning of passages compared to tractor scraping, often using an automatic timer to flush every 2 hours;
- Passageways keep cleaner with improved foot health.

There are however a number of concerns where flood washing is proposed. These concerns include:

- If the system is operated when cows are present, flood water will splash onto the legs and udders of some cows and often into the cubicle beds;
- Wash water is recycled dirty water, providing a risk to udder health and an unpleasant aroma;
- An alternative system is required during breakdowns;
- It may increase the spread digital dermatitis.

The slope of the scraper passage is critical to maintain the momentum of the flood water. A slope of 2–4% will maintain the momentum with a minimum volume of water. The success of the system depends on creating a wave of water around 20m in length, 75mm in depth moving at a velocity of 2m/sec. This will generally allow the water to be in contact with the slurry for 10 seconds.

Once a passage has been flood washed, the water is stored and re-used. The more often the water is re-used, the more contaminated it becomes with slurry and the thicker it becomes. The smell of the flood wash liquid will also increase significantly with use. It is recommended that to minimise the problems of odours and keep the liquid manageable, 20% of the volume of the stored water should be changed each day. It is also advisable to have separation lagoons which allows solids to settle in the first 2 lagoons resulting in cleaner water in the third, which is used for the flush washing. It is probable that lagoons will need planning permission.