Dairy yard

Sprinklers and fans

Priorities for cooling cows

1. Use shade first

Minimise heat gain – block solar radiation

2. Use sprinklers and fans

Maximise heat loss – encourage evaporative cooling

Every dairy yard in Australia should be fitted with sprinklers.

Sprinklers encourage heat loss through evaporative cooling. Sprinkling cows before milking can lower breathing rates and increase milk yields.

If cows are cool when leaving the dairy in the afternoon, they eat more overnight.

While the production benefits are real, most farmers nominate the reduction in flies as one of the best thing about using sprinklers in the yard!

Dairy yard sprinklers

Sprinkled concrete loses heat via evaporation and conduction through contact with the cooler water. This reduces its ability to re-radiate heat to the cows standing on its surface.

Sprinklers can be used to wet cows too so they can off-load heat via evaporation. A small amount of heat is also off-loaded via conduction from hoof contact with the cooler concrete surface.

Strengths:

- Low capital outlay.
- Can be easily fitted to any dairy yard (or feedpad) with a concrete floor.
- Effective method of cooling a large number of cows quickly.

Limitations:

- If droplet size is too small cooling will not be effective.
- Use in high humidity conditions actually increases heat load on cows.
- Without adequate air movement, cooling using sprinklers is not effective.
- Need access to a reliable water supply.

Case study

Dairy yard sprinkler system

Background

Lindsay is convinced of the benefit of sprinkling cows in hot weather and has been doing it for more than 30 years as part of his summer routine.

The current system was installed in 2000 and includes 'wobbler' sprinklers set up over the dairy yard and a spray curtain installed on the roof line at the entry onto the platform.

The infrastructure is well designed and allows cows to stand in the yard in comfort even in high temperature conditions – a factor in motivating cows to travel to the dairy.

Farmer's name: Lindsay

Facts about this sprinkler system:

- Designed by: Lindsay
- Installed by: Lindsay and farm staff
- Lifespan: Set up 10 years ago and to date nothing has needed to be replaced

Other cooling infrastructure on this farm:

- Spray curtain at dairy platform entrance
- Large fan in dairy

'Wobbler' sprinklers running across the yard, suspended by steel cables and support posts.

Case study

On 30°C days sprinklers are used before milking. On days over 35°C the herd is brought into the yard from the paddock and sprinkled with water for at least 2 hours before the afternoon milking. In the November 2009 heatwave (during which the max. daily THI exceeded 80 for 10 consecutive days) the farm only lost 1 L/day with cows on concrete under sprinklers for 6-8 hours/day.

Lindsay's dairy yard is 50 m long and 18 m wide and holds up to 500 cows. The system has these specifications:

- Four rows of wobblers each with three sprinklers across the yard at spacing of 4.5 m. Each row about 7 m apart.
- Height of sprinklers above cows is 3 m at side of yard and 2.8 m in the middle.
- Use existing dairy pump 70 psi.
- No filter used.
- 25 mm diameter pipe.
- Constant use of sprinklers, no on/off cycle is used.
- Channel or bore water for dairy yard, yard drains to effluent pond, then utilised through irrigation system. No water leaves the farm.

What would you change?

Knowing what you know now...

Lindsay would put support posts into concrete to provide stronger support to cables and sprinkler lines, as some posts have bent.

Comments from the experts

This property's dairy yard sprinklers are effectively spaced and elevated so that all the dairy yard can be wetted when operated and are not located within reach of the cows. They apply large droplets that effectively wet the cows' hair and skin.

The sprinklers are not operated based on a set on/off cycle to conserve water. However, the wobbler sprinklers appear to have a lower flow rate, as compared to the oscillating garden variety sprinklers.

Wobbler sprinkler.

Steel posts that supports the water pipelines and allow the individual cables to be tensioned.

For more information about sprinkler systems, go to page 57.

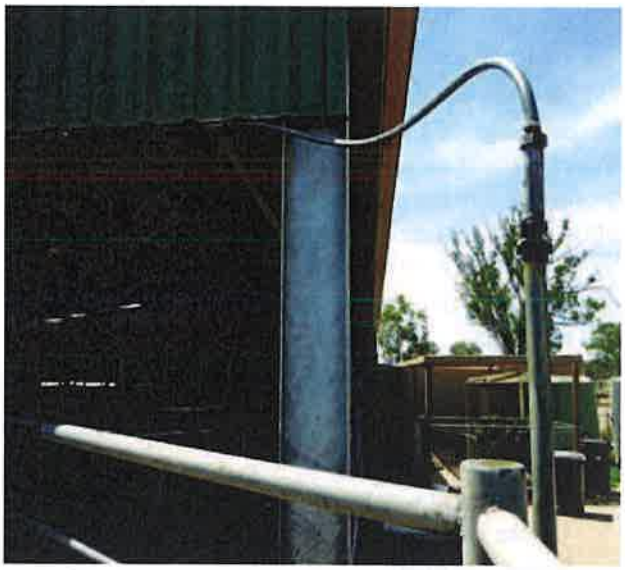
Spray curtains

Spray curtains are another cheap cow cooling option that has the added benefit of keeping flies out of the dairy – appreciated by both cows and people!

Spray curtains can be used in dairy yards but are normally attached to the underside of the dairy shed roof between the yard and the platform.

The example shown was constructed for less than $100 using 19 mm black polyethylene attached to the roof with garden sprinkler sprays inserted into the pipe every metre. It is about 2.5 m above the cows' feet level.

The sprinklers generate a semi-circle spray pattern that is directed towards the yard side of the shed.



Spray curtain water supply and filter.

Polyethylene pipe attached to the dairy shed roof for the spray curtain.

Spray curtain in operation.

Comments from the experts

The spray curtain is a cheap and effective complement to any dairy yard sprinkler system.

It not only helps keep the dairy shed cool for cows and milkers, it also reduces fly numbers in the dairy – by washing flies off cows on entry and providing a wall of mist that prevents flies from entering the shed.

Fans

Increasing airflow from 0 m/sec to 1 m/sec increases heat loss from a wet cow three-fold.

Fans can therefore be a useful complement to sprinklers, especially on warm to hot days when there is little or no wind.

Fans can also be useful in the dairy shed in conjunction with a spray curtain, as in the example shown.

Fans only help cool cows when:

- the air temperature is lower than the cow's body temperature (39°C)
- the surface of the cow is wet.

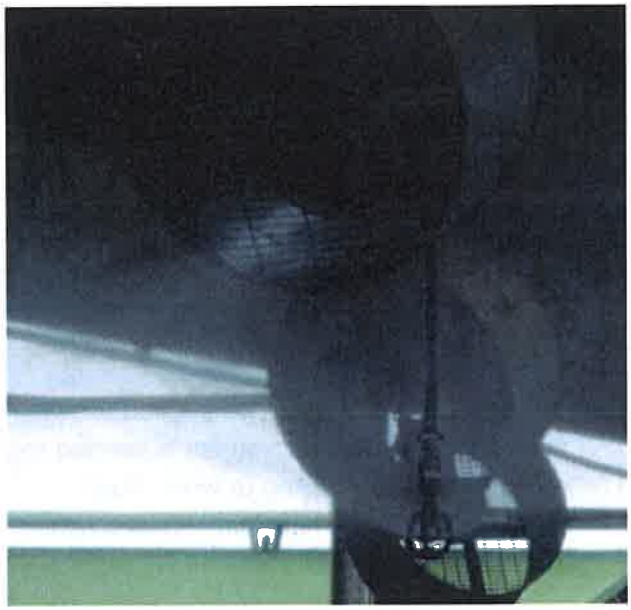
In a dairy yard, fans should be mounted above sprinklers so they remain dry and tilted 20-30° down from vertical so that they blow down to the floor, between and underneath cows. If fans are aimed too high, their effectiveness will be reduced.

They are usually placed in a row with their back to the prevailing wind, and not blowing into the dairy.

Fans range in cost from about $550 to $2,000 each, depending on their design and capacity.

Check the efficiency rating of the fans and buy the most efficient. Only use fans with sealed motors.

For more information about fans, go to page 59.



Fans in a covered dairy yard tilted correctly to direct airflow downwards to the floor.

A large industrial fan can be used in conjunction with the spray curtain to keep air circulating in the dairy shed.

Keys to success

Remember that for evaporative cooling to be effective, the cows' skin needs to be wet – but not so wet that water dribbles down the udder.

Sprinklers

- **AIM FOR** a high-volume sprinkler with medium-to-large droplets – avoid a fine mist.
- **COVER THE** entire dairy yard, so that all cows are wet in the first 10 minutes.
- **CONSERVE WATER** by installing a timer and running sprinklers on an on/off cycle.
- **COWS SHOULD** not be packed too tightly – sufficient air movement is needed to allow evaporative cooling to work. Poor ventilation results in high humidity and health problems.
- **SPRINKLERS POSITIONED** along the sides of a dairy yard need to be mounted high enough to project water up and over cows so it falls from above (ideally 2 m). This will minimise wetting of udders and the risk of mastitis. It will also prevent water being thrown directly into cows' ears.
- **IF COWS'** teats do get wet then either allow time to dry, or dry them with a paper towel before putting cups on.

For more information about sprinkler systems, go to page 57.

- **AVOID WETTING** cows immediately after milking to prevent teat disinfectant from being replaced with contaminated water while teat orifices are still open.
- **PRE-WET THE** dairy yard by hosing, flood washing or sprinkling for the hour before cows arrive for afternoon milking. This helps dissipate the heat stored in the concrete.

Fans

- **ENSURE ADEQUATE** number of correctly spaced fans of suitable airflow capacity for the area.
- **ORIENTATE TO** work with the prevailing winds.
- **TILT DOWN** so they blow air between and underneath cows to enhance whole body cooling.
- **OPERATE ON** a temperature threshold to reduce unnecessary power use, and machine 'wear and tear'.

For more information about fans, go to page 59.

Feedpad

Shade structures

Permanent shade structures over feedpads (or freestalls) can make a big impact on overall farm productivity.

Shade provided here encourages cows to keep eating.

Permanent shade sheds are an investment that provides excellent protection from solar radiation – but they must be well designed and constructed.

Permanent shade sheds

An effectively designed and built shade shed provides:

- sufficient room for resting and standing
- comfortable, hygienic lying surfaces
- clean, dry surfaces for standing and feed placement
- a safe environment to minimise injury
- smooth, quiet stock movement.

Note that the orientation and roof design of the shade structure will influence the amount of solar radiation that it can block.

Strengths:

- Fast to set up, but with a long useful life – at least 25 years.
- Doubles as a feedout facility,
- Can be used to protect pastures and prevent soil pugging during prolonged periods of rainfall.
- Can be used to break the growth cycle of parasites such as cattle tick and reduce the need for chemicals.
- Can be fitted with evaporative cooling systems such as sprinklers and fans (see Section 3b).
- Can be converted into a freestall or integrated with loafing pads if well designed.

Priorities for cooling cows

1. Use shade first

Minimise heat gain – block solar radiation

2. Use sprinklers and fans

Maximise heat loss – encourage evaporative cooling

Limitations:

- Location on farm is not always ideal for paddock rotation.
- High capital cost to provide shade. Cost depends on amount of concrete; type of roof, strength of structure required to support roof and the effluent management system.
- Must have an effective system for handling effluent and run-off, otherwise cow comfort and production may be compromised.
- Need to comply with regulatory authorities (e.g. local council building permit for solids roof structures).

Case study

Low-cost earthen feedpad with solid-roofed shade structure

Background

On-going drought conditions meant Karen and Ian had to re-think their whole approach and in 2007 they changed their operation from an extensive grazing system to a hybrid system. The herd is fed a total mixed ration (TMR) from November to March and then from April to October it is grazed and provided with supplements.

Karen and Ian estimate that they experience up to 100 days/year where heat load affects their cows, so they knew that providing more shade to the herd was a priority. Impressed with what they saw on a trip to the United States, Karen and Ian built two separate, covered earthen feedpads.

Farmers' names: Karen and Ian

Facts about the earthen feedpad:

- **Designed by: Karen and Ian, in consultation with structural engineer**
- **Built by: Local builder and farm labour**
- **Lifespan: At least 25 years**

Other cooling infrastructure on this farm:

- **Sprinklers in dairy yard**

Feedpad 1 on the western side located within 300 m of dairy. Note the central drive alley with portable concrete troughs on either side.

Feedpad 2 on the eastern side

Case study

Two separate compacted clay feedpads share a central drive alley, with portable concrete troughs on each side of the drive alley. The long axis of each rectangular feedpad is orientated north-south. The feedpads each have a raised earthen loafing area located beneath a long shade shed (also running north-south).

The shade sheds, in combination with the feedpads, have meant a substantial reduction in the dips in milk production that resulted from extended hot weather.

Each of the two feedpad shade structures took about three weeks to construct at a cost of about $60,000 (including the earthworks, materials and installation of the shade sheds, troughs and fencing).

- The earthen pads are constructed from on-site clay that was raised and compacted.
- Pads drain to the southern end, then run-off is conveyed into the farm's irrigation recycle system.

There is a 5-6% slope away from the drive alley and shade sheds to enhance drainage from where the cows stand to eat and to drain stormwater away from the sheds.

Each feedpad is scraped daily to break up the manure pads and enhance drying of the manure. This is part of the property's mastitis risk management plan.

A land plane is used weekly to scrape manure from the heavily trafficked areas between the feed troughs and the shade sheds. This is deposited on the other side of the shade sheds to form a dry, aerated manure pack that the cows can lie down on.

The feedpads are scraped each year. All the manure is removed and spread directly back on to the property.

The ground slopes away from the drive alley and shade sheds at about 5-6% to enhance drainage.

Water falling on the shade shed roof flows into gutters, then into several downpipes and underground piping that is directed to the recycle system. No stormwater from the roof lands on the feedpad floors.

Ian's comment

Because we experience so many hot days a year, we estimate that we save around 2 litres/cow/day due to our improved heat load management.

Over more than 100 days and at 35¢ a litre, that is equivalent to about $33,000 a year in extra milk income!

Case study

Due to the earthen floors, the orientation of the structure is north-south to allow floors to dry out – the sun will strike each part of the floor at some point over the day. The shed has the following dimensions:

- Shade structures – 108 m long x 9 m wide.

Posts are located 9 m apart along the length of the shed; 8 apart across the width of the shed

- Height of roof is 3.8 m on the gutter side; 4.2 m on the high side.
- The roof is single pitch, sloping from east to west at 4.5%.

The shade sheds consist of square tubing support posts that are bolted to concrete footings. H-section steel is used as the trusses, then C-section purlins. Corrugated iron sheets form the roof.

- Rectangular tubing support posts: 125 mm x 75 mm, 5.0 mm wall thickness
- Trusses (steel channel): 150 mm wide
- Purlins: 200 mm
- Footings: 600 mm diameter x 1,200 mm deep; 25 MPa concrete

Roof design of the shade shed.

The central drive alley is constructed from rubble, sourced locally. The central drive alley slopes to the south.

The concrete feed troughs are portable. Their external dimensions are 6 m long, 0.88 m wide, 0.85 m high – back wall, 0.6 m high – front wall.

There are two round 2,700-litre water troughs on each feedpad, at each end of the shade sheds on the side closest to the feed troughs.

What would you change?

Knowing what you know now...

Feed troughs

In future Karen and Ian will remove the concrete feed troughs and construct a concrete drive alley and install a nib wall. This will allow feed to be delivered on the concrete surface and more importantly it will be able to be pushed-up regularly reducing feed wastage.

Karen and Ian estimate that they are losing between 5-10% of feed delivered through spillage from the troughs, so it is well worth the effort.

Ian's management tip

In our area we have low to medium winter rainfall so the earthen feedpad is okay as it can normally dry out well between episodes of rain.

There has been a higher incidence of mastitis as compared to the pasture-based system we used to operate pre-drought, so we have to be really pro-active with our mastitis risk management.

We scrape the pads every day to give them a chance to dry out and after heavy rain we move the herd to dry pasture paddocks in order to reduce the incidence of mastitis from the wet feedpad.

Case study

Location of sheds

Karen and Ian would construct the shade sheds further away from the central alley.

As the sun moves across the sky the shaded area from the sheds moves in the opposite direction. At the western feedpad, the shaded area moves towards the central alley in the afternoon.

If cows want to sit down in the shaded area they have to sit in the heavily manured area between the feed and water troughs.

Ideally, they could sit in a cleaner area of the pad, which could be achieved by increasing the distance between the shade sheds and the feed troughs.

Location of water troughs

We'd also re-locate the water troughs. If they were located on the far side of the feedpads (between the boundary fence and the shade sheds) it might encourage the cows to sit down in the cleaner area of the pad.

Comments from the experts

This style of earthen feedpad / shade structure is well suited to a farm operating a hybrid feeding system in low-moderate rainfall areas. This farm is in southern NSW.

The two shade sheds provide just over 4 m^2 of shade per cow at midday, based on the current herd of 470 cows.

The north-south orientation means that the 'shaded area' shifts across the pads during the day, which means it spreads manure deposits over a larger area as the cows move with the shade.

The raised floors and pitched roofs allow stormwater to be effectively managed and not end on the pad floor, so there are no wet patches for cows to lie in. They also enhance convective air movement from under the roofs.

The drainage system controls and directs all run-off away from the pads.

Current position of water trough is between the feed troughs and the shade sheds. This is where a high percentage of manure is deposited, which often means cows are sitting in fresh manure.

Better position for water troughs – between the boundary fence and shade shed.

Case study

Low-cost feedpad with shade cloth structure

While the shade cloth over this feedpad is not wide enough to provide shade to cows all day, with some modification it may be a cost-effective cooling option for some farms.

- Feedpad is 72 m long and runs east-west.
- Shade cloth has a 90% solar rating (doubled over).
- Feeding space is 0.7 m/cow, with the standing area concreted out to 3 m from the nib wall.
- Drive alley is 5 m wide (two 1 m concrete strips with 3 m of gravel in between).
- Height from ground to shade cloth is 4.4 m.

This structure cost about $50,000 to construct, including concrete feed alleys, water troughs and the shade cloth structure.

The feedpad is close to the dairy and cows are happy to move to the dairy and they arrive unstressed. The dairy yard is fitted with sprinklers and cows are sprinkled before milking.

Farmers' name: Ian and Cathy

Facts about the feedpad:

- Designed by: Ian and Cathy
- Built by: Ian and Cathy, and family

Other cooling infrastructure on this farm:

- Sprinklers in dairy yard

Central drive alley with two concreted feed alleys. Each feed alley is partially covered with shade cloth. Cows that can access the shade on the southern side of the feedpad during the day stay more comfortable than the cows exposed to sunlight on the northern side of the pad.

What would you change?

Knowing what you know now...

- Add another row of shade cloth to increase the area shaded per cow (especially on the northern side).
- Plant trees around the perimeter of the loafing area, but fence off. The trees here have died, or are dying due to the concentration nutrients and compaction.
- Increase the size of the loafing area on both sides of the feedpad to allow more space per cow and provide alternate areas to rotate cows during wet weather.
- Improve the surface and drainage of the earthen loafing areas surrounding the feedpad for better mastitis risk management.
- Consider adding a sprinkler system along the feed alley/drive alley partition above the cows' heads to increase cooling capability.

Obviously, this type of structure is suited to a drier climate where the herd does not need protection from the rain – this farm is in south-east Queensland.

Each side has an earthen loafing area.

Case study

Higher-cost concrete feedpad with solid-roofed shade structure

This farm in northern Victoria has opted for a covered concrete feedpad to house its 600 cows for up to six hours a day in summer. The aim was to reduce the milk and fertility losses in hot weather and they have noticed a big improvement in rates of mastitis.

The feedpad was built in 2000 and cost $300,000. The roof was erected in 2008 for about $260,000.

- The shed is 200 m long.
- The roof is 18 m wide.
- The drive alley has a width of 6 m and each feed alley is 5 m wide.
- The roof is 4 m high at the eaves – pitched at 20°.
- Open ridge vent is 600 mm wide.
- 50 m^3 of concrete were used in the footings.
- 550 m^3 of concrete was used in the feedpad.
- Water troughs are located along each side of the shed.

The feedpad is easy to clean and minimal labour is required as it takes only 45 seconds to flood wash each cow alley.

- The floor is sloped to make flood washing easier.
- 50 kL of water is used per day for flood washing.
- Solids and sand in effluent is collected in a large concrete sump.
- Liquid effluent passes through a weeping wall to a holding pond.

(The effluent system could do with upgrading to handle the increased volume of runoff).

The north-south orientation means that cows are exposed to the sun in the mid-morning and afternoon. In summer, the afternoon sun is likely to increase the heat load of cows on the western side of the pad.

The feedpad is located right next to the dairy holding yard, which is fitted with sprinklers. Cows are sprinkled pre-milking and for longer periods on very hot days.

The cooling capacity of this covered feedpad could be further enhanced at modest cost by installing sprinklers along each side of the central drive alley.

Farmer's name: Rob

Facts about the concrete feedpad:

- **Designed by: Rob, in consultation with structural engineer**
- **Built by: Contractors**

Other cooling infrastructure on this farm:

- **Sprinklers in dairy yard**
- **Some trees**

Permanent covered concrete feedpad with iron roof and a central, open ridge vent in the roof apex.

Pitched roof has a ridge vent to let heat and humidity escape. It also influences convective air movement.

Central drive alley sloped to the centre to prevent rainfall that comes through the ridge vent contaminating the feed.

Keys to success

- **MANAGEMENT IS** easier if the shade structure is located close to the dairy, as staff can monitor the herd while preparing for milking or post-milking clean-up.
- **CONSIDER THE** effects of prevailing winds, radiation from the sun and rainfall. Structures need to be able to withstand extreme weather conditions.
- **DAILY SCRAPING** of earthen feedpad surfaces helps manage the risk of mastitis.
- **AN EFFECTIVE** system for handling effluent and run-off.

For more information about solid-roofed shade structures, go to page 53.

Feedpad

Sprinklers and fans

Permanent structures over feedpads (or freestalls) provide shade which minimises cows' heat gain. Incorporating infrastructure such as fans and sprinklers assists heat loss through evaporative cooling.

The combination of shade, sprinklers and fans means farmers have much more control over environmental conditions.

These structures require significant investment and professional advice is critical to success.

Priorities for cooling cows

1. Use shade first

Minimise heat gain – block solar radiation

2. Use sprinklers and fans

Maximise heat loss – encourage evaporative cooling

Feedpad/freestall sprinklers and fans

Strengths

- Fans are very effective at cooling cows when used in conjunction with sprinkling – their combined effect is greater than the impact of each alone.
- Provide effective air movement and cooling in confined spaces such as covered dairy yards, sheds and freestalls.

Limitations

- Require a concrete floor to manage effluent run-off.
- Fans require close access to sufficient power – a limiting factor in many rural areas of Australia.
- Fans are expensive to buy and run.

For fans to cool cows effectively:

- the ambient temperature must be lower than the cow's body temperature
- the cow's skin must be wet (through sprinkling or sweating).

Case study

Freestall shed evaporative cooling system

Background

This large herd operation uses a Total Mixed Ration (TMR) feeding system and has covered freestalls and dairy yard that provide year-round shade and shelter. Fans and sprinklers complement the shade, providing high levels of evaporative cooling in hot conditions. The whole operation has been dubbed the 'Cow Hilton'!

The fully roofed facility and cooling infrastructure allows the property to artificially control the climate, and subsequently optimise cow comfort and production. The farmer reports that the investment in this infrastructure has reduced the impact of climate variation on milk production.

The fans in the freestalls (and dairy) are:

- orientated to work with the prevailing winds
- positioned above feed alleys about every 6 m; in the stalls – every 12 m
- pitched down towards the ground, so that they force air between and underneath the cows to enhance whole body cooling
- operated on a temperature threshold to reduce unnecessary power use and machine 'wear and tear'
- set to come on above 21°C full time.

Two types of fans are used – 'old' fans are used in the feed alleys and the stalls have 'new' ones installed.

- Old fans have 900 mm blades and move air at the rate of 285 m^3/minute with a 0.45 kW motor.
- New fans have bigger 1300 mm blades and move air at the rate of 840 m^3/minute with a 1 kW motor.
- Estimated cost: $65/hour to run 60 fans in one freestall (1,000 cows).
- The fans are from Fanquip.

Sprinklers are located in the freestalls (and dairy) and are operated based on several environmental triggers or temperature thresholds, as well as a timed on/off cycle. This reduces operating costs and system 'wear and tear'.

- Sprinklers can be adjusted to alter the droplet sizes depending on the climatic conditions.
- Sprinklers in the freestalls are 1.7 m above flooring.

Farmer's name: Michael

Facts about this system:

- **Designed by: US agricultural engineer**
- **Built by: Contractors and family**

Other cooling infrastructure on this farm:

- **Solid-roofed dairy yard with fans and sprinklers**

Fans set 2.3 m above cows, angled down. All fans push air from west to east with the prevailing wind.

Side view of the fan.

Case study

Sprinklers mounted above the head stanchions in a freestall barn. Droplet size can be adjusted.

Sprinklers spraying water on cows in the feed alley.

- Sprinklers are spaced 3 m apart above the feed alleys, so all feed alleys can be wetted when operated.
- Spray pattern is about 1-1.5 m back from sprinkler.

The sprinkler on/off cycle in the freestall area operates in the following way:

- at 21°C a two-minute on; 13-minute off cycle
- above 25°C reduce the off cycle by 20% for every 1°C above 25°C
- at 35°C they are on for two minutes; off for three minutes.

Water use in the freestalls (including drinking water and sprinkling):

- 140 litres/cow/day in summer
- 80 litres/cow/day in winter.

Michael's comment

Farmers need to do their own research, look carefully at sheds here and overseas, and use an engineer with experience in designing these systems.

Comments from the experts

This property is an excellent example of an evaporative cooling system incorporating fans and sprinklers that complements a covered (roofed) freestall or feedpad. It provides a high level of control over climatic conditions, and optimises cow comfort and production.

The sprinklers in the freestall shed:

- can be adjusted to alter droplet size to suit the conditions
- are operated on several environmental triggers (temperature thresholds) as well as a timed on/off cycle
- are well spaced so that all the alley ways can be wetted when operated.

The fans in the freestall shed:

- are orientated to work with the prevailing winds
- are pitched down towards the ground so they force air around and under the cows to enhance whole body cooling
- are operated on a temperature threshold to reduce unnecessary power use and machine 'wear and tear'.

Fans

Increasing airflow from 0 m/sec to 1 m/sec increases heat loss from a wet cow three-fold.

Fans can, therefore, be a useful complement to sprinklers, especially on warm to hot days when there is little or no wind.

Fans only help cool cows when:

- the air temperature is lower than the cow's body temperature (39°C)
- the surface of the cow is wet.

Fans should be mounted above sprinklers so they remain dry and tilted 20-30° down from vertical so that they blow down to the floor, over and around cows. If fans are aimed too high, their effectiveness will be reduced.

They are usually placed in a row with their back to the prevailing wind.

Fans range in cost from about $550 to $2,000 each, depending on their design and capacity.

Check the efficiency rating of the fans and buy the most efficient. Only use fans with sealed motors.

For more information about fans, go to page 59.

This is a 'Shade Tracker' evaporative cooling system in use on a farm in the US. This computerised system adjusts the amount of water output according to the temperature and relative humidity, and follows the shadow of the shade shelter through the day. This ensures that the cool air is always blowing into the shade.

This US farm is using 'Korral Kool' evaporative coolers. These are a fixed cooling system used in conjunction with automatic blinds fitted to each side of the shade shelter to shade the cows in the mornings and afternoon when the angle of incidence of the sun is at its greatest. This photograph shows the blinds in the half way position.

Keys to success

- **MANAGEMENT IS** easier if the feedpad/freestall structure is located close to the dairy, as staff can monitor the herd while preparing for milking or post milking clean-up.
- **CONSIDER THE** effects of prevailing winds, radiation from the sun and rainfall. Structures need to be able to withstand extreme weather conditions.
- **USE AN** engineer with experience in designing these systems.

Section 4

Stock water supply

Priorities for cooling cows

1. Cool drinking water

Maximise heat transfer – provide cool drinking water

2. At any location

Maximise access – provide multiple water points

Access to drinking water

When cows drink, they transfer heat from their bodies to the water via conduction.

Effective heat transfer depends on differences in temperature. Cold water transfers more heat away from the cow than warm water.

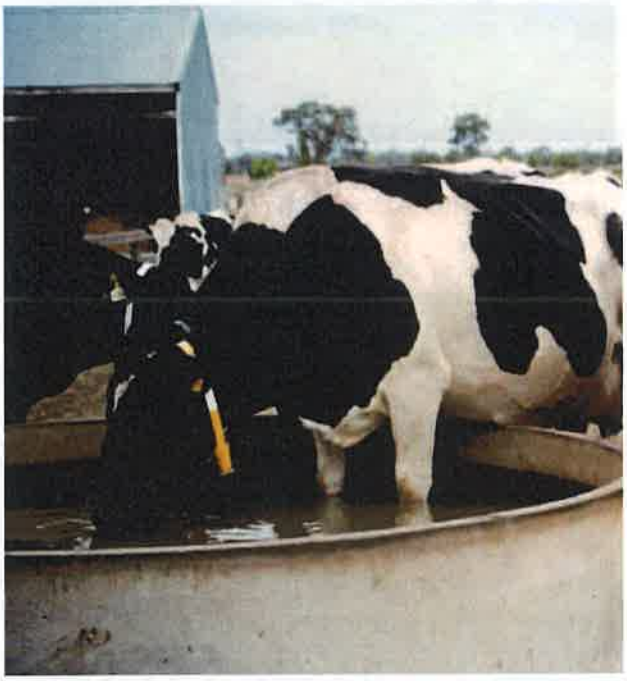
Allow 200-250 litres/cow/day in hot weather – double the normal intake.

Make sure cows have access to cool water wherever they are during the day or night.

Volume and space requirements

Milkings cows usually drink after milking and they can consume up to 20 litres of water/minute. Around 30% of daily consumption occurs just after milking, so water should be easily accessible as soon as cows leave the dairy (not a 1-2 kilometre walk away).

- Optimal drinking temperature is 15-20°C.
- Troughs should be 600-900 mm high (cow feet level to top of water point).
- Water depth should be 150-200 mm to maintain cool temperature and reduce debris accumulation.
- Water reticulation systems should supply at least 20 litres/cow/hour.
- Each trough should be able to hold at least 200-300 litres of water with a minimum flow rates of 10 litres/minute.
- Trough volume can be reduced to about 100 litres if the flow rate is increased to 20 litres/minute.



This cow is transferring heat from its body via contact with the water.

This trough is on the southern end of a feedpad.

This stainless steel trough is located at the intersection of the main laneways leading to/from the dairy.

On this farm each feedpad has two circular concrete troughs.

Water quality

Saline water can affect animal health and affect the effluent management system.

- Stock water supplies should be analysed regularly to check salinity levels.

Install troughs adjacent to feed alleys and dairy yards so cows have to place their head through the fence to access water.

- Make sure you can get access to troughs for cleaning.
- Use a bung to drain the trough into the effluent management system.
- Plumb troughs so that water can drain back into concrete feed alley or yards after cleaning.
- Rectangular water troughs are easier to drain and clean.
- Ensure manure does not build-up around the base of troughs.

Stock water points should be cleaned at least weekly to remove any feed residue or other contaminants.

Water point locations

Paddocks and laneways:

- Provide watering points in every paddock, as this will keep cows grazing longer in hot weather. If they have to leave the paddock to get a drink they often do not return to graze.

Dairy exit:

- A large water trough on the exit side of the dairy is a must.
- Locate in wide passage, preferably on the outside of cow traffic curve.

Dairy holding yard:

- Install troughs along sides of dairy yard so cows have to place their heads through the fence to drink.

Earthen feedpad:

- Place troughs away from the feed source on the down-slope side of the pad, so that water can drain directly into the effluent management system. This helps to minimise the formation of wet patches throughout the feedpad.

Concrete feedpad:

- Place water troughs within about 15 m of the feeding table.
- Locate away from the feed alley to prevent feed contaminating the water.
- Locate within the feedpad complex, so that spillage and flushing can be directed into the effluent management system.

Freestall shed:

- Locate water troughs at the crossovers to prevent feed contaminating the water and to reduce the incidence of cattle blocking each other in the alleys.
- Provide at least 5 cm of trough space per cow in systems where cattle are confined for 24 hours/day – with at least two points for every group of cows.

A shaded circular concrete trough positioned at the end of the dairy yard.

This rectangular concrete trough runs alongside the feedpad.

Keys to success

- **AVOID RUNNING** black poly pipe along the ground, as water will become hot before reaching the watering point.
- **LARGE VOLUME** concrete troughs help keep drinking water cool.
- **LOCATE TROUGHS** in shaded areas where possible.
- **USE HIGH-PRESSURE** flow systems that allow rapid refilling of water troughs.
- **DESIGN TO** cater for increased demand in hot weather.
- **CONSIDER FUTURE** increases in herd size or changes to farm layout.
- **LOCATE SO** that water is not contaminated by feed.
- **DESIGN AND** locate to allow easy, frequent cleaning.
- **MANAGE MANURE** build up around troughs.

Section
5a

Design considerations

Shade cloth structures

Several forms of shade cloth structures are available including span structures (such as the case study on page 20), peaked sail structures, cantilever structures as pictured below and tent like structures with large central supports.

Design considerations for maximum effectiveness and useful life

Fabric material

For dairy cattle, use shade cloth which blocks at least 80% of sunlight, with a minimum 300 gsm (grams per square metre). Green or black coloured material is preferred. Shade cloth fabric should last at least 10 years. Higher quality and tighter weave fabrics last longer but cost more.

Shade cloth fabric can deteriorate relatively quickly with exposure to sunlight, dust, accumulated debris and water. Flexing will encourage deterioration and wear as well as failure or loosening of connections. Shade cloth is also prone to bird, insect and rodent attack and areas not able to be hosed down or easily inspected for maintenance are particularly prone.

Note: Cows are also not keen on going from bright areas to dark areas and prefer dappled shaded spaces to dark spaces, so they tend to get used to a shade cloth structure more quickly than a solid-roofed structure, provided the cloth is not billowing or flapping noisily.

Fastening fabric to posts

Shade cloth must have sufficient tension applied to it to prevent the cloth from damage during windy conditions. The flexible and adjustable connections between the fabric and the support posts are therefore critical structural components.

The shade cloth fabric can be held to posts in different ways, ranging from load-carrying straps to chains and u-bolts and in the most advanced form adjustable cables and turnbuckles.

How long the connection lasts usually depends on how well it distributes the point load at the stanchion to the fabric. Reinforcing cables and seams help.

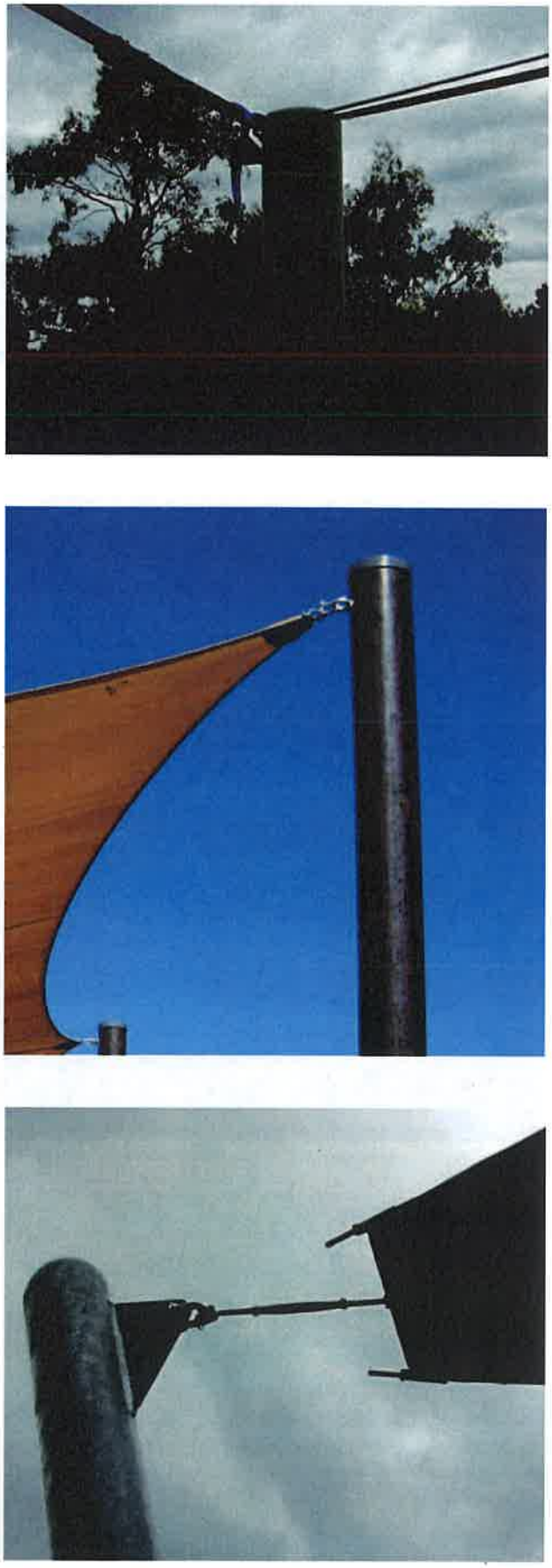
If excessive flexing of fabric is permitted the flapping can generate unacceptable noise during wind events which can disturb cows and irritate people. However, compared to metal frames and buildings, shade cloth structures suffer minimal temperature or water related deformation.

If a cable or cable connector fails due to over-tensioning, it can cause instantaneous and catastrophic structural failure.

Turnbuckles for tensioning cable supported shade cloth structures are prone to loosening or failure through repetitive loading so they should be inspected regularly and tightened or replaced.

Chain connections should be avoided. In the event of overstress, breakage of a link can lead to the launch of a projectile whereas a cable will fray or unravel, allowing time for repair, replacement or escape from injury.

Shade cloth structures can become a hazard if damaged by storms. Blown cladding can provide serious injuries whilst broken cables and unsecured shade cloth can whip.



Different fastening methods.

Support posts and foundations

Ensure structural grade steel is used. For rigid framed and flexible shade cloth structures the wind loads, dead loads and live loads imposed on the structure need to be transferred through the structure into the ground. The foundations which secure each post to the ground are therefore critical structural components.

Deep, concreted footings are essential as the posts are subject to a 'bending moment' and need to transfer stresses into the ground, as well as to stop the structure lifting. Each post should be rigidly attached to a wide steel plate which is mounted on the foundation using bolted connections. Galvanised and threaded starter bars extending from the footing reinforcement are better for holding the plate than dynabolts.

Apart from central supports these posts usually lean against the applied horizontal load to maintain the tension rather than being vertically upright. They need to be free standing in a farm situation. Guy cables must be avoided.

Deep footings should be left to cure for an extended period before bearing any load.

Avoid collisions between animals and vehicles with posts, cables and cladding. If possible, position posts outside the animal traffic area so they are not in contact with manure and water or interfere with washing (If are located in the yard, place a raised concrete or PVC sleeve around the pipe to reduce corrosion potential).

Height

If the shade cloth is suspended too high, it will limit the area of shaded footprint.

A minimum height of 4.0 m is recommended to ensure:

- cows do not interfere with it and are happy to walk under it (Low shade cloth structures can put cows off entering an area)
- effective installation and use of sprinklers and fans
- machinery can readily traffic the area without risk of tearing it or burning holes in it with their exhaust pipe
- adequate airflow underneath the structure.

Orientation

The height of the structure, the angle of winter and summer sun and the required area of shaded footprint govern the orientation of the shade structure – north-south or east-west. If the structure is aligned east west the passage of the sun will generally ensure that the northern side of the structure is more exposed to sunlight than the southern.

Drainage

Drainage from shade cloth must be considered, particularly if the paving is earth. Ideally, any drainage should be directed to formed drains rather than earth that is subject to animal traffic.

WEAKNESSES IN shade cloth structures are usually associated with:

- cyclic loading conditions
- lack of fabric strength
- inadequate fabric reinforcement at connections
- connections to stanchions which are prone to fatigue
- failure of footing connections, leading to loose posts
- excessive spans which can lead to billowing
- corrosion of metal
- degradation of fabric
- rain, hail or debris accumulating on top of the shade cloth.

Stresses on shade cloth structures

A shade cloth structure must be strong enough to withstand three types of load: 'wind load', 'dead load' and 'live load'.

Wind load

Wind load is usually the largest load carried by a light-framed agricultural or industrial building taking the form of a tensioned shade cloth or a rigidly clad framed structure.

Wind loads impose unbalanced forces on a shade cloth, generating ripples or waves that may lead to premature failure of fabric or other components. This problem can be alleviated by ensuring that the shade cloth is adequately tensioned.

Horizontal wind loads can also contribute to structural failure. If the angle of inclination of a roof or shade cloth is 15° or so, it will generate lift (The roof behaves like the leading edge of an aircraft wing). Lift can be minimised by either flattening the inclination of the roof or shade cloth to between 10 and 14° or installing it with an inclination in excess of 20°. Roof angles of 15 to 18° should be avoided.

Sailcloth structures are particularly prone to ripping in response to high wind loads, inadequate fabric strength, lack of structural reinforcement and excessive spans which can lead to billowing.

Dead load

Dead load refers to the weight of the structure (downward force due to gravity) which must be withstood by the posts. Bracing in frames or cables supporting shade cloth are usually employed to 'stay' or brace posts.

Posts supporting shade cloth are frequently installed at an angle to help provide tension but this can also contribute to instability when the cable support is removed.

While the dead load of a metal clad framed structure is high by comparison with a shade cloth structure, the load imposed by shade cloth should not be underestimated, particularly if the loading is not well distributed. Cloth impregnated with dust or supporting leaves, twigs, hail, ponded water or wetted from beneath by sprinklers can also be quite heavy and the cables and connections which form the structural system are not light.

Live load

Live load refers to brief, temporary loads such as those associated with someone on a roof, hailstones or rainfall cascading down a roof, water pooling on the canopy or being shed through or from shade cloth.

If metal clad frameworks and shade cloth structures are not designed to carry human traffic it is not surprising that failure occurs when they do. Safe OH and S practice must restrict access to these structures.

While shade cloth is designed to pass some light and air as well as water it is not unusual for some of the gaps in the mesh to be clogged. If the mesh gets clogged and water pools, an excessive live load is possible which can lead to fabric failure at best or structural failure at worst.

If you intend to install a shade structure, consult a registered builder or structural engineer who understands how to design and build a structure which will withstand these loads. Alternatively , if you are buying a package shade cloth structure ensure that structural computations are supplied, the installers are experienced and local building regulations are met.

ADVANTAGES OF a shade cloth structure over a solid-roofed shade structure:

- Lower cost (less than half that of a solid-roofed structure covering the same area).
- You have the option of removing the shade cloth in the cooler months of the year. (Ensure that you store the fabric to protect it from vermin.)
- If fabric degrades or is damaged it can be easily replaced with better material and the connections upgraded to better reflect farm needs.
- If severe storms are forecast, the fabric can be furled or removed to limit damage.
- If well designed, installed and maintained there is no greater risk of failure of these structures compared with other farm buildings.
- Different types of fabric offer different degrees of light transmission.
- Technological developments are rapidly leading to better fabrics and connections and longer lasting structures.
- If well made, the posts and foundations are long lasting.
- It is possible to extend shade cloth structures without the same attention to drainage that a solid-roofed structure requires.

Solid-roofed shade structures

Solid-roofed structures may have a pitched roof (such as the case studies on pages 23 and 39) or a flat roof (such as the case study on page 34).

Design considerations for maximum effectiveness and useful life

Roofing material

Roof material may be aluminium or white galvanised iron sheets to increase the rate of solar reflection. This should last at least 25 years.

Roof height

For good machinery access, the roof height should be at least 3.7 metres at its lowest point and at least 4.5 metres at the shed centre (for entry/exit).

Roof pitch

Lower roof pitch results in slower air movement (e.g. 1:4 pitch or less). Steeper roof pitch results in greater air movement (e.g. 1:3 pitch is suggested for warmer climates).

Enclosing a shelter using sheeting, a blind or even a furled shade cloth can contribute to significant horizontal wind loads which can contribute to structural failure. If the angle of inclination of a roof or shade cloth is 15° or so, it will generate lift. (The roof behaves like the leading edge of an aircraft wing).

Lift can be minimised by either flattening the inclination of the roof to between 10 and 14° or installing it with an inclination in excess of 20°. Roof angles of 15 to 18° should be avoided.

Ridge opening

Provide a continuous open ridge to promote air movement (i.e. convective heat dissipation via the 'stack effect').

Recommendations for open ridge space:

- 50-75 mm/3.0 m of shed width (DPC et al 2009).
- 300 mm + 50 mm per 3 m width for sheds greater than 6 m wide for northern Australia (Davison et al 1996).

Eave overhang

The recommended overhang for open-sided sheds is 900 mm. Eave overhang is dependent on feedpad/ freestall configuration, and on eave height and degree of protection required.

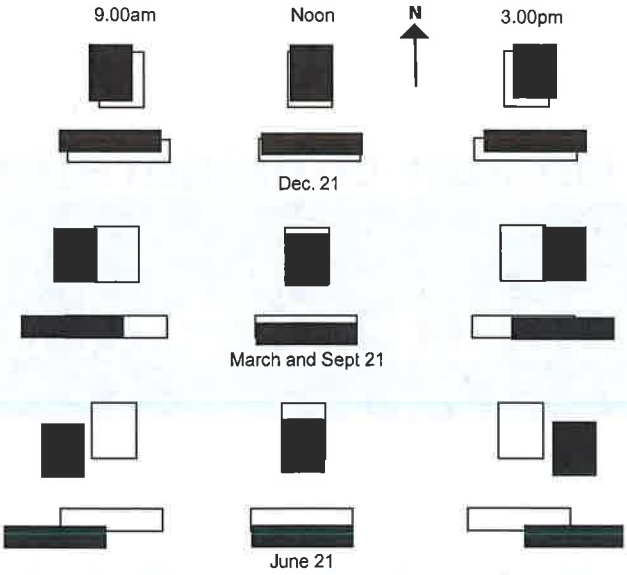
Guttering and downpipe design

As per state plumbing code (engage a qualified design engineer).

Orientation – east-west or north-south

With an east-west orientation, and an area of 2.5 to 3 m²/cow, part of the floor area under the roof will be in shade all day. Extending the floor about one third its length on both the east and west to 3 to 4 m²/cow will place feed and water troughs under shade at all times, which will encourage intakes. More dung will be dropped in the shaded area, which will need frequent cleaning to avoid the risk of mastitis. East-west orientation, therefore, works best for concrete floors.

If concrete is too costly, the north-south orientation works best. It works well for a compacted clay or gravel floor because the sun strikes every part of the floor area under and on either side of the roof at some time during the day. This helps to keep the floored area dry and restricts pathogen build up. A shaded area of 2.5 to 3 m²/cow is adequate if feed and water troughs are placed away from the shaded area. In regions where temperatures average 30°C or more for up to 5 hours/ day during some period of the year, the east-west orientation is deemed more suitable.



Shed profiles at 9 am, noon and 3 pm at four different times of the year.

Effluent management system

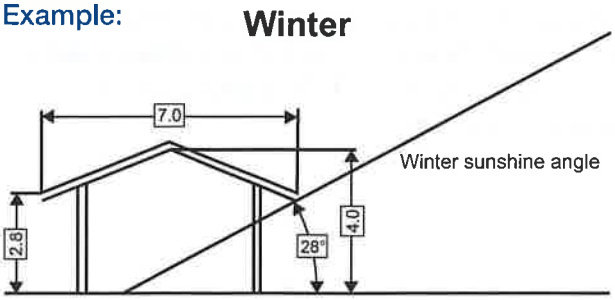
An effective system for handling effluent and run-off is essential, otherwise cow comfort, health and production may be compromised. Refer to section 8.0 – Guidelines for Victorian Dairy Feedpads and Freestalls (DPIV 2009).

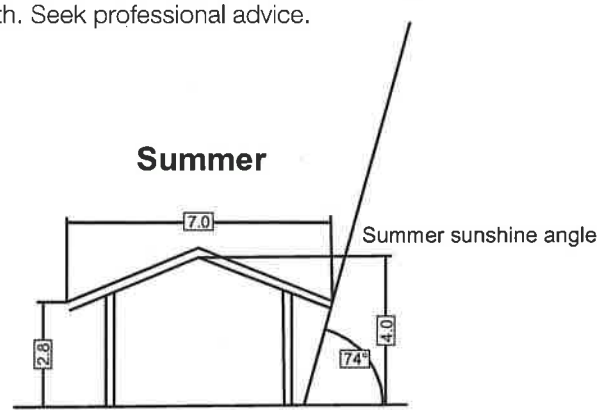
Solid-roofed structures need to comply with regulatory authorities, e.g. a local council building permit is required.

Winter and summer sunshine angles

Winter and summer sunshine angles are important, as they determine how much of the floor area receives sunshine at some time during the day, given a shed's roof height and width. Seek professional advice.

Example:





Note the position of the water trough, grooving to help prevent cow's slipping, water run-off from the roof to lane, high eaves and pitched roof to facilitate ventilation. The shed runs north-south to use sunlight to dry cow standing areas.

This roof slope is 18° with a 500 mm vent at the apex. Eaves are 4.3 m high, and 6.9 m at apex. The shed runs north-south with 3% slope on patterned cement floor. Feed troughs are 1.2 m wide inside, 400 mm high and 100 mm thick.

Note the poor drainage due to the lack of slope. The freestall shed has fans and sprinklers but is not linked to good drainage – a recipe for high mastitis levels.

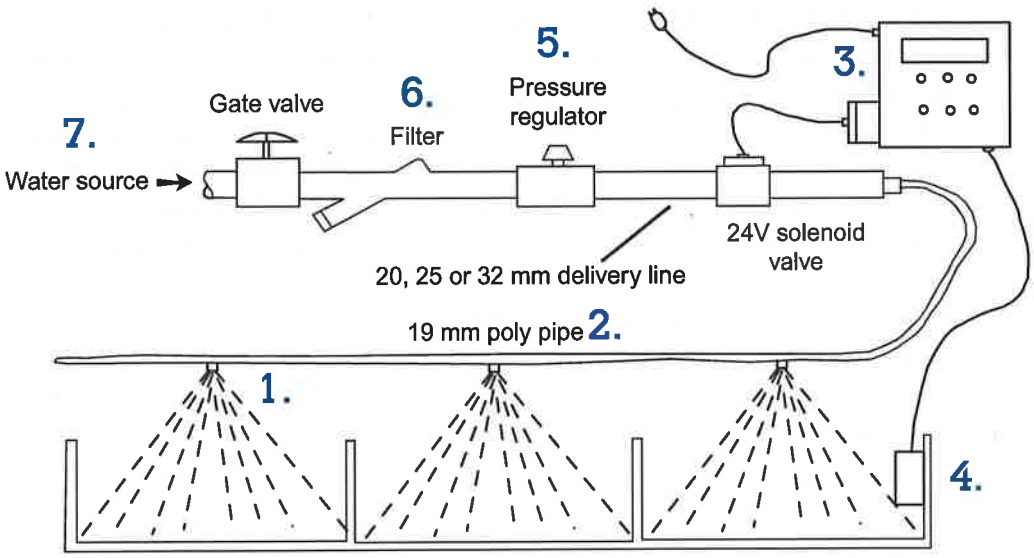
Sprinklers could be fitted above head lock stalls or at the back of the cow alley in the shed.

Note that the sprinklers above the feed line spray onto the cows' backs. The feedpad runs north-south and has a sloping roof to reduce the western sun projecting into the cow resting area.

Design considerations

Sprinklers

Design considerations for maximum effectiveness and useful life



1.	Sprinkler nozzles	Several types are available. Large irrigation sprinklers can throw water over a large area. Overhead wobbler sprinklers and garden sprinklers positioned on sides of dairy yard or overhead use less water and do not throw water as far. (Garden sprinklers on sides of dairy yard may be ineffective during windy conditions. Set up system so you can turn banks of sprinklers on each side of dairy yard on/off independently). Droplets must be medium-large to allow water to penetrate the hair coat and wet the cow's skin. Best position depends on type and capability of selected sprinkler and pumping system. However, as a guide, sprinklers should be spaced at intervals of 1.5 to 2 times their wetted radius, so there is a slight overlap of wetted areas. Sprinklers should be set at least 2 m above the floor of the dairy yard.	
2.	Pipes	Sizes must suit the length and area to be sprinkled, the number of sprinklers and their flow rates. Here is a guide:	
		Shed length:	Diameter of main delivery line:
		– Up to 40 m	20 mm
		– 40-60 m	25 mm
		– 60-100 m	32 mm
		– More than 100 m	2 x 50 m runs of 25 mm
		PVC piping does not twist, but polythene is cheaper. To maintain low water temperatures, all exposed pipe should be painted white and header tanks should also be shrouded, insulated and painted white.	

3.	Controller / timer	A 15-minute adjustable type timer, attached to remote control valve (solenoid) will enable you to apply sufficient water on cows while minimising wastage. Aim to sprinkle cows for one to three minutes, which should be sufficient to wet them effectively, and then shut off for the remainder of each 15-minute cycle to allow the water to evaporate before the next cycle.
4.	Temperature sensor	Temperature sensors can also be attached to the controller to allow sprinklers to automatically switch on when cows are in the dairy yard at a certain temperature, for example, at 25°C. (Note: if an automated system is installed, ensure you can manually override it if necessary).
5.	Pressure regulators	Low-pressure sprinklers work best (0.70 kg/cm^2), producing larger droplets, less mist and drift of spray (Large droplets penetrate the coat better. Smaller droplets can create an insulating layer of water on the cow's coat that can make the cow hotter instead of cooler – droplets are required, not mist). A main pressure regulator can be installed at the beginning of the pipeline or smaller regulators on each sprinkler nozzle can be used. Operating pressures are usually in the range of 14 to 20 m (140-200 kPa). Low pressure will produce larger droplets and less mist and drift of spray.
6.	Filter	Sand or dirt may clog the sprinkler nozzles, so a filter is required between the water supply and solenoid valves that control the water flow to the spray nozzles or drip outlets. A common filter type is a plastic filter with a grooved disc filter element. A 200 micron filter is used for spray cooling and an 80 micron filter for drip cooling. Filters should be capable of a flow rate of up to 1.4 litres/second for spray and 0.8 for drippers.
7.	Water	Ideal water temperature is 15-20°C (Note: providing cows with chilled water at the dairy to help reduce heat load may reduce water intake and therefore be counter-productive). Water containing more than 1000 mg/L TDS (total dissolved solids) should not be used in reticulation systems because of corrosion (dissolves concrete!) An allowance of 0.5-1 litre/head/hour is common for spray cooling dairy cows. Remember that excess water use will create waste management issues. For more complex or larger installations it is necessary to properly design the system taking into account friction losses, flow rates and component selection.

Design considerations

Fans

Design considerations for maximum effectiveness and useful life

Fan sizing, type and placement	Seek professional advice from a registered engineer and/or manufacturer. A pitched roof and open ridge vent should be considered before fans during the planning of a new covered structure. Fans range in cost from about $550 to $2,000 each, depending on their design and capacity, plus installation. Check the efficiency rating of fans. Fans should be mounted above sprinklers so they remain dry. Only use fans with sealed motors. Spacing is determined based on the fan's operating flow rate (m^3/minute). As a guide: • 900 mm blade, 285 m^3/min with a 0.45 kW motor – spaced every 6 m • 1,300 mm blade, 840 m^3/min with a 1 kW motor – spaced every 12 m (assuming the base of the fan blade is 2.3 m above cow feet level). Ensure that fans used have the capacity to move the volume of air required at >2.0 m/second. If cows are tightly packed, airflow will need to be greater. When used in open spaces, larger-capacity fans are required because they are operating against static pressure, so their efficiency is lower. Doubling the operating capacity of the fan does not double the distance covered by the fan, but it will increase costs. Be prepared to modify the placement of fans and add additional or larger-capacity fans if required. It is best to discuss with an expert before you proceed.
Fan orientation and pitch	To minimise operating costs, locate fans to take advantage of prevailing winds at the site. The fans should be tilted 20-30° down from the vertical so they blow down to the floor, to ensure air is forced down around and beneath the cows. This will enhance evaporative and convective cooling. Tilting the fans towards the ground also reduces interaction between groups of fans that are located in series with each other, improving operating efficiency.
Fan operating cycle	When operated in conjunction with sprinklers, fans will usually be initiated first (i.e. start to operate a lower temperature than sprinklers). Sprinkler on/off cycles can then be stepped up at different temperature trigger levels (as per case study farm described on page 42). If fans are in the dairy they should run continuously when the Temperature Humidity Index (THI) is more than 72.
Maintenance	Keep the safety grill around each fan free of cobwebs and dust to maintain their maximum efficiency and effectiveness.

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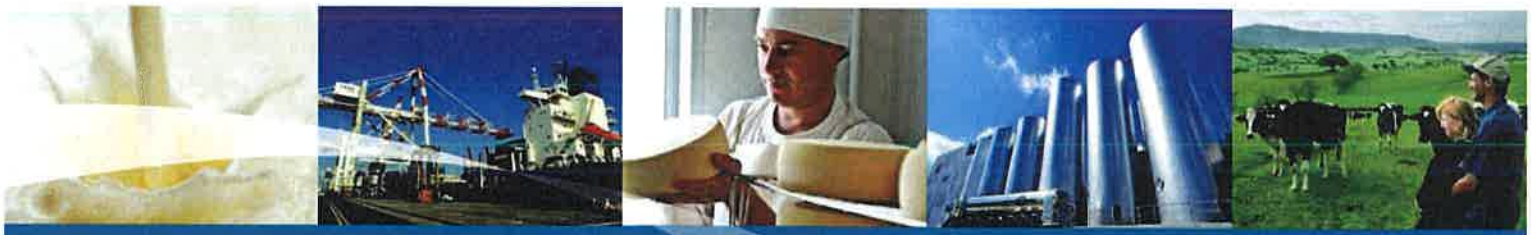

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