

5

Use good milking technique and a consistent routine

The main mechanism of transmission of contagious (or 'cow-associated') mastitis is spread of pathogens from cow to cow at milking.

Bacteria generally responsible for contagious mastitis are *Staph aureus* and *Strep agalactiae*. These bacteria live on the teat skin or in the udder. Spread occurs when infected milk contaminates the teat skin of clean quarters or other cows. This can be by milk on milkers' hands or teatcup liners, through splashes or aerosols of milk during stripping, and by cross flow of milk between teatcups.

Staph aureus bacteria invade udder tissue and can form pockets of infection (micro-abscesses) and scar tissue. The infection is difficult to cure, especially during lactation, so prevention is essential. In contrast, *Strep agalactiae* tend to locate in duct areas of the udder where antibiotics are effective. It is very sensitive to penicillin, so treatment has a relatively high cure rate.

Strep uberis has become the major cause of mastitis in Australia and NZ. Although it usually behaves as an environmental pathogen, sometimes *Strep uberis* can behave as a contagious pathogen too.

Spread of mastitis infections can be minimised by good hygiene, keeping teat ends healthy, using milking equipment that is operating well, and disinfecting teat skin after milking.

Technote 1 describes characteristics of environmental pathogens and *Strep dysgalactiae*.

Technote 4.4 discusses response to antibiotic treatment during lactation.

The *Strep agalactiae* FAQ sheet describes how to eliminate this pathogen.

Technote 8 describes good milking hygiene that maintains teat condition.

Technote 9 describes the natural defence mechanisms at the teat end.

Coagulase-positive *Staph aureus* is a major pathogen. Coagulase-negative staphylococci are common in heifers but are usually eliminated spontaneously.

Characteristics of contagious mastitis bacteria

Characteristic	Staph aureus	Strep agalactiae
Reservoir of infection	Infected udders of cows. The surface of the teat skin, especially in cracks and sores.	Infected udders of cows. Although the bacteria is described as an 'obligate parasite', it can survive on teat skin, milkers' hands and clothes, floors and equipment for up to three weeks.
Spread	Cow to cow at milking, by contaminated milk, mostly on liners and hands.	Cow to cow milking; contaminated milk mostly on liners and hands. Spread is very rapid.
Cow susceptibility	All lactating cows are susceptible especially if there is teat end damage or teat sores. Infection can occur in first calf heifers although it is not common.	All lactating cows are susceptible. Infection can occur in first-calf heifers before entering the shed – possibly from sucking each other as calves.
Clinical signs	<p>Most infections have no clinical signs although abnormal, uneven, lumpy udders and occasional flecks or wateriness of the milk can occur.</p> <p>A small proportion of cows have severe episodes – the cow is sick, the quarter is painful and grossly swollen and has an obviously abnormal secretion.</p> <p>Gangrenous forms, with massive tissue damage and toxæmia, occur rarely.</p>	<p>Infection can cause high rates of clinical disease, with hard swollen quarters.</p> <p>Affected glands may have recurrent acute episodes and eventually become uneven and firm with watery foremilk containing clots.</p> <p>Many infected quarters are subclinical.</p> <p>Intermittent clots may be seen especially at the teat end at the finish of milking.</p>
Bacterial shedding	Bacteria are shed intermittently from subclinical quarters. If a single milk sample is taken from an infected quarter, there is about a 70% chance of isolating the bacteria. Freezing samples may enhance the likelihood of obtaining a positive sample.	Very high numbers of bacteria are shed, especially in the early stages of infection when 100 million bacteria per mL of milk may be present.
Cell counts	About 50% of infected cows have ICCC >500,000 cells/mL. Cell counts from infected quarters rise and fall cyclically throughout lactation.	Most infected cows have ICCC >500,000 cells/mL although ICCC can fluctuate widely from below 200,000 to above 1,000,000 cells/mL.
Milk quality	Bacteria are passed in milk, but numbers in the bulk tank are low and do not cause a problem.	There is a potential for very high numbers of bacteria to be shed in bulk milk, occasionally enough to exceed Total Plate Count (or Bactoscan) thresholds.
Management during outbreaks	<p>Take cultures from 10-20 cases to confirm the identity of the bacteria.</p> <p>Correct milking machine and milking technique faults. Check teat disinfectant and application. It is essential to disinfect teats and improve the health of teat skin.</p> <p>Because treatment does not cure all infections, culling is an important part of a control program. Create a preferential culling list based on clinical history, cell count history, Dry Cow Treatment history, age, production and stage of lactation.</p> <p>Consider blanket Dry Cow Treatment.</p>	<p>Take cultures from 10-20 cases to confirm the identity of the bacteria. This infection can be eradicated if all factors contributing to spread are corrected and existing infections are treated or removed.</p> <p>Correct milking machine and milking technique faults. Check teat disinfectant and application. It is essential to disinfect teats and improve the health of teat skin.</p> <p>Segregate all cows with infected quarters, not just clinical cases, from the herd.</p> <p>Use blanket Dry Cow Treatment at drying-off.</p> <p>Consider a closed-herd policy. Prevent re-introduction by testing purchased cows and any treated cows before they are allowed to return to the main herd.</p>

5.1 Ensure that cows enter the milking shed willingly by use of good stockmanship

Human-animal interactions have marked effects on the behaviour and productivity of farm animals, including dairy cows (Hemsworth 1997).

The success of machine milking depends on the willing co-operation of an animal. The milk ejection reflex is blocked if cows are nervous or frightened. If the milk ejection hormone (oxytocin) doesn't reach the udder, then milk let-down doesn't occur. Milk yield is higher, milking time per cow is shorter, stripping yields are reduced, and cows dung and urinate less frequently when the milking environment is pleasant, repeatable and predictable for the cows. For example, Seabrook (1994) found that cows entered the milking shed more quickly (10 seconds versus 16 seconds per cow) and there was less dunging on the cow platform (3 versus 18 times per hour of milking) when cows were milked with 'pleasant handling' compared with 'aversive handling'.

Behavioural responses of the cow to milking can be assessed also by the frequency of kicks and steps (the 'KiSt response') although careful observation and analysis is required to separate environmental effects (e.g. flies) from machine effects and operator/machine interactions (Mein 1997).

Research on commercial dairy cows in Australia has shown that high fear levels occur if stockpeople use a high percentage of negative interactions, such as slaps or hits with a poly-pipe, when handling their cows (Hemsworth et al 1999). In contrast, fear of humans is low in situations where stockpeople use a high percentage of positive interactions such as patting, talking and slow deliberate movement.

Some farmers calve their heifers before the rest of the herd so that they can spend additional time familiarising them with the milking shed and milking routine. Other people calve their heifers with the herd so that cows accustomed to the milking routine 'lead the way' for heifers. Both methods are valid strategies for introducing new cows to the shed and either offers an alternative if people are having problems training their heifers with their current method.

The preferred aim is to create a quiet, non-threatening, caring maternal environment for new mothers who have recently been separated from their calves.

Confidence – High

Recent Australian research confirms that quiet handling affects cow behaviour and production. On-farm experience shows that the heifers' familiarity with the milking shed is of particular benefit to herds with tight calving patterns, large herds with small-framed heifers or seasonal herds that do not have extra labour at the start of lactation.

Research priority – Low

Methods of achieving changes in cow handling by stock people and milking staff may be important.

Technote 6.1 gives more details about interpreting cow behaviour.

- When handling cows, people should use positive behaviours. Only use negative behaviours when necessary, such as when a cow refuses to walk forward when it is being moved.
- If a cow is behaving as required, and if there is opportunity, positive behaviours should be used.
- It is important to recognise that the consistent use of even moderate slaps and hits will result in cows becoming fearful.
- See the CowTime project Shed Shake Up information 'Go with the flow' for good tips on managing cow movement. www.cowtime.com.au

Confidence – Moderate

Adopting management practices to detect early cases of mastitis has been a successful control strategy in herds with *Strep uberis* problems. It is assumed all herds would benefit.

Research priority – High

It would be worthwhile to evaluate in-line conductivity or other automated means that reduce the labour required to detect clinical mastitis cases.

Countdown Downunder strongly recommends foremilk stripping of all quarters of all cows in the colostrum mob.

Farmers should consider continuing foremilk stripping during the first month of lactation.

5.2 Consider foremilk stripping for all cows in their first month of lactation

Foremilk stripping is the careful removal of 2-4 squirts of milk from each quarter before milking. An effective treatment, described in the Countdown Downunder Farm Guidelines for Mastitis Control, is to squeeze the base of each teat between the thumb and first two fingers, then pull gently downwards.

Role of foremilk stripping in detecting clinical mastitis

Foremilk stripping is used to detect clots, wateriness or discolouration in the first few streams of milk. Changes that persist for more than three squirts suggest that a cow has mastitis. Quarters with a few flecks only in the first three squirts may be left untreated and checked again next milking.

Early detection of clinical mastitis is one of the main potential benefits of foremilk stripping. When practised at the beginning of lactation, it helps detect clinical cases earlier at a time when the clinical infection rate is highest, as well as accustoming cows to having their teats touched and providing an effective signal for milk ejection.

Routine forestripping, even of freshly calved cows, is not widely practised in Australia and implementation of this recommendation will require many farms to change their current practices. The benefits of checking all quarters during the colostrum phase increases as the occurrence of clinical cases during the calving period (especially *Strep uberis*) increases in importance in Australia. Field experience in herds with outbreaks of *Strep uberis* mastitis indicate that cases detected early are more likely to respond to treatment. In a recent small study in New Zealand, seven clinical infections (of which five cultured *Strep uberis*) were detected by forestripping 46 animals in the first five days after calving.

Whether people choose to continue inspecting foremilk strippings after the colostrum phase will depend on the circumstance of the herd. These days, routine foremilk stripping is a relatively uncommon practice in Australian herds because:

- The practice requires an additional labour unit in most rotary dairies and in larger one-operator herringbones.
- The practice is time consuming and, furthermore, there is increased risk of repetitive strain injury for the milking staff in large herds. Some milkers reduce the time and risk by stripping only one or two teats per cow per milking, e.g. the left half udder at morning milkings and right half udder at evening milkings.
- If done poorly, it contributes to the spread of pathogens by splashes and aerosols of milk from the infected quarter transferring to teats via the milkers' hands.
- The chance of finding a clinical case is low, especially in well managed herds. A clinical incidence of two per month per 100 cows means that the milker has to forestrip 12,000 teats to find one clinical case.

Although these disadvantages may outweigh the potential benefits of foremilk stripping in herds with low BMCC and low incidence of clinical infections, there are good reasons for routine foremilk stripping during periods of high risk, such as when:

- The clinical new infection rate is high.
- BMCC is approaching a penalty threshold.
- Clots are found on the milk filter.

When clots are found on the filter, and the cause is not established, every quarter of every cow should be checked for abnormal milk by foremilk stripping before applying the machine at the next milking. In large herds, spreading the job over two milkings may be a practical approach to achieving a thorough inspection.

In-line filters designed to detect mastitis in individual cows can be fitted to the long milk tube, between the clawpiece and the main milkline, in a position where they can be easily read. Milk flows through a wire mesh designed to trap large particulate matter, such as milk clots. This material is viewed through a transparent window in the filter. In-line filters can give users a false sense of security (Blowey and Edmondson 1995) as they only detect mastitis when:

- The filters are checked after each cow is milked.
- Infected cows are passing milk clots rather than watery milk.

Current knowledge does not support the general use of the Rapid Mastitis Test, individual cow cell counts (ICCC) or hand-held conductivity meters to identify clinical cases requiring treatment. These tests were designed to detect subclinical mastitis and not all test-positive cattle need to be managed as clinical cases.

These tests can be used to identify suspicious quarters that require close visual examination for mastitic changes in the udder or in the milk. In some very specific situations, such as treatment of a *Strep agalactiae* outbreak in a herd, they may be used to determine which cows will receive antibiotics.

New automatic sensing systems for monitoring mastitis in individual cows are becoming more reliable. The performance of such sensing systems is improved markedly when they are linked with reliable cow ID, data storage and processing (Mein, 2010).

A reliable automatic monitoring system should be capable of facilitating at least three main tasks for effective mastitis management:

- Prompt detection of clinical cows, or simplifying the search for clinical cows if clots are found on the milk filter sock, especially during the high risk period of early lactation.
- Providing regular, reliable lists of the 'millionaire' cows (those with ICCC greater than 1 million cells/mL) to simplify management of BMCC, especially during the last three months of lactation.
- In the last month of lactation, providing a reliable list of cows with sub-clinical mastitis to simplify the selection of cows for antibiotic therapy at drying off.

None of the commercially-available monitoring systems can achieve 100% accuracy in carrying out these three tasks. The best that can be achieved, at present, is to simplify these tasks by reducing the size of the pool of suspect cows (Mein, 2010).

Role of foremilk stripping in reducing new infection rates

In the absence of post-milking teat disinfection, Phillips found that careful forestripping significantly reduced the incidence of mastitis in a New Zealand research herd (Frost and Phillips 1970). However, foremilk stripping did not affect the new infection rate of mastitis in South Australian herds where effective post-milking teat disinfection was practised (Feagan and Hehir 1972). It is unlikely that it plays a significant role in reducing infection rates in modern herds.

The 'Cow-side mastitis tests' FAQ sheet describes conductivity meters and the Rapid Mastitis Test.

Confidence – Moderate

Extensive data, mainly from the United States, show benefits in milk quality when environmental contamination is reduced.

Research priority – High

It would be worthwhile to evaluate the effect of teat preparation on environmental streptococcal infections in Australian conditions. Similarly, a comparison of flamed udders, 'one-step preps' and techniques currently used in the industry could be assessed in a pre-milking hygiene trial.

Technote 27 describes how to fix areas that make udders muddy.

Dirty teats should be washed with clean, low-pressure water.

The 'Pre-milking teat disinfection' FAQ sheet discusses issues associated with pre-dipping.

5.3 Put cups on clean, dry teats – only wash dirty teats

Mastitis risk is a 'numbers game'. The new infection risk is reduced by keeping bacterial numbers low on or near the cows' teat-ends. A simple method developed and validated by Dr. Pamela Ruegg (cited in Reinemann, 2010) for scoring udder hygiene has proved an invaluable tool to monitor the effect of the cow environment on udder cleanliness. Udder hygiene scores have been shown to be correlated with bulk tank somatic cell count and mastitis infection rates on farms in the USA. Although environmental conditions are quite different in Australia compared with Wisconsin, the tool is likely to have value in any climate. The tool allows for a quick and easy assessment (usually no more than 20 minutes), and more importantly, provides a quantitative measure of performance that can be used to test the efficacy of different animal management strategies.

Overseas research has shown significant advantages to reducing water usage and milking dry teats (Galton et al 1986, McKinnon et al 1983). Udder surfaces should be dry (even if dirty) and teats should be clean and dry before milking.

Milking wet teats is unacceptable for both mastitis and milk quality issues. The incidence of intramammary infection is highly correlated with the number of mastitis pathogens on the teat-end at milking (Galton et al 1988). Research at Cornell University (Galton 1995), in Australia (Hubble and Mein 1986) and elsewhere suggests that wetting any portion of the udder above the teats without subsequent drying will result in dirty, bacteria-contaminated water draining into the top of the teatcup liner during milking. This practice reduces milk quality (mainly by increasing coliform counts) and increases the risk of mastitis (mainly from environmental pathogens such as coliforms and *Strep uberis*) (Smith and Hogan 1997).

The risk of infection from environmental pathogens appears to increase with increasing level of milk production per cow, and with increasing concentration of cows in large herds.

Udder washing practices

High-pressure hoses are good for washing away manure from the dairy floor and railings but they are inappropriate for udder washing. If a low-pressure, high-volume water supply is combined with manual cleaning by the operator, much less water will end up in unwanted places on the cow (udder, legs, underside and flanks).

Relatively clean, but dusty teats can be cleaned effectively without water using a single cloth per cow moistened with sanitiser. A 'one-step prep' approach has been successfully employed overseas. One such product recommends:

- Wearing gloves.
- Dry removal of contaminants.
- Pre-stripping and pre-dipping using the hand to grasp the top of the teat and rub firmly down the teat with a spiralling motion. Rotation around the teat three times ensures dip is worked into all surfaces of the teat barrel, then followed by two vigorous wipes across the teat end.
- Drying the teat with a paper towel or cloth with the same action including the teat end.

Rewashable Chux-type towels (and other more substantial but still ultimately disposable cloths) can be washed then rinsed in 200 parts per million chlorine and spun dry in a washing machine. Teats are dry cleaned with a gloved hand, and the dusty teat is then cleaned with the moistened towels using a similar

action described above. The cloths are folded in four parts and a clean surface is presented to each teat. A new cloth is used on each cow. The teats air-dry quite quickly and are ready for cluster attachment.

Dairy water quality

Good quality water must be used in dairies, for preparation of cows, general hygiene and cleaning of equipment and the plant.

Water used in the farm dairy may be obtained from a number of sources (rain, river or creek, bore or underground spring and dam or irrigation channel). As the water passes through the atmosphere, over the surface of land and through the soil it may change in quality in many ways. It collects physical impurities (sediment, turbidity, organic matter), mineral impurities (hardness, alkalinity, iron) and biological impurities (algae, micro-organisms and bacteria).

Impurities can cause problems with the performance of chemicals used in dairy hygiene and mastitis control. Many quality problems can be avoided or minimised by prudent sourcing and correct storage of the water, or by treatment. Under standard Australian conditions, it is unlikely that treated water on tap will be available or feasible on a regular basis. Nevertheless, water treatment is likely to become an important issue as the industry strives for higher quality milk.

Suitable treatment can be achieved by the use of commercial equipment (expensive, automatic) or by farmer-built treatment systems (cheaper batch treatment but can be semi-automated). Details of quality problems commonly experienced in dairy farm water supplies and suggestions for their treatment are given in Hubble (1981a, 1981b, 1989a, 1989b, 1990) and Flowerday (1998).

In situations where water is suspect bacteriologically, it can be treated with chlorine to a level of 0.5 parts per million free residual chlorine (as measured by a swimming pool test kit). The water must be free of suspended clay and organic material prior to treatment.

Udder flaming

The major source of bacteria and organic matter that enters the milk vat is from the teat and udder. Hair is a good base for organic matter to collect and accumulate. A hairless udder collects less manure and dirt and is easier to clean. Under muddy conditions in Australia, udders and teats are washed but often not dried. Significantly more water accumulates on a hairy udder than on a smooth one. This water is laden with bacteria and contaminants. Inevitably, it runs down to the teats, collects around the teatcup mouthpiece and enters the milking machine.

Udders are easier to clean, and easier to keep clean, if udder hair is kept short by clipping or flaming once or twice per year. Flaming is much quicker and more efficient. Udder flaming is a procedure using a soft, warm flame from a propane torch to de-hair the lower parts of an udder.

Udder flaming is not painful. Cows tolerate the process very well, and it is significantly quicker, less stressful and more thorough than clipping. Flaming is best performed on a still, dry day in a shed that has adequate ventilation. To flame a whole herd, one extra person in the pit is required – adding about 15 minutes per 100 cows to the milking time. Flaming should occur before milking and before wetting. All cows should be flamed as soon as they enter the milking herd. Typically, the process needs to be repeated every 3-6 months. The rate of re-growth depends on cow hairiness and climate.

Technote 7.3 discusses water quality in teat disinfectant solutions.

Udder flaming is performed by:

- Adjusting a torch flame so that it is 150 mm high and throws a yellow flame.
- Slowly passing the flame about 150-200 mm below the udder ensuring that the hair is singed to the skin but not set alight.
- Blowing flames out and brushing ash away with a gloved hand or a soft car brush.
- Making sure the floor of the udder, especially around the teats and around the back of the udder, is flamed and brushed.
- Removing ash before attaching clusters at the milking so that it does not end up in the milk.

Confidence – High

Research and field experience has shown the benefits of correct timing of teatcup application are quicker milking out and improved teat condition.

Research priority – Low

Although higher yields resulting from correct timing of teatcup application have not been demonstrated under Australian conditions of minimal pre-milking udder preparation, further research is not warranted.

The first touch by the milker (the signal to trigger milk ejection) can be one of the following:

- foremilk stripping;
- pre-wiping teats;
- a brief manual palpation of each quarter (to feel for hot or hard quarters); or
- a brief rub-down of each teat to remove loose dirt.

As a simple check, watch the claw bowls during the first minute of milking. When teatcups are applied too soon, milk flow into the claw bowl typically slows or stops after about 15-20 seconds of initial flow, then full flow does not start (or restart) until about one minute after cups on.

5.4 Put teatcups on when teats become plump with milk

Picking the best time to attach teatcups has benefits of cleaner quicker milking out, improved teat condition and, frequently, higher milk yield per cow (Hamann and Dodd 1992, Reneau et al 1994).

Reneau et al (1994) concluded that the optimum 'window of time' to apply teatcups is 60-90 seconds after the cow's teats and udder are first touched by the milker. This window allows time for milk ejection to occur in most cows while making optimum use of the milk ejection hormone, oxytocin (Gorewit 1983).

Although firm but gentle touching or rubbing of teats is a very effective stimulus for milk ejection, it is not the sole stimulus. Cows are creatures of habit. The sights and sounds of milking and the predictability of a calm, consistent milking routine can elicit a good milk ejection in most cows, especially in the first six months of lactation.

Whatever routine is adopted in any given herd, the golden rule is to choose a set of procedures that allows or, preferably, requires each milker to be absolutely consistent at every milking.

In many herds milked with an otherwise good milking routine, the simplest way to match the timing of cup application with milk ejection would be to delay the time of cups on by 30-60 seconds. On rotary platforms, this change might require nothing more than moving the cups-on operator to a position about 60 seconds past the cow entry point.

Putting cups on too soon usually results in teatcup crawling during the first minute of milking. Teatcups crawl higher up the teats because milk flow slows or stops if cisternal milk is removed before the main milk fraction is ejected from the alveoli into the milk ducts and cisterns. When teatcups crawl early in milking, milk harvesting becomes less complete and less efficient near the end of milking. This happens because the milk pathway between the cistern and teat sinus becomes restricted more quickly, after the peak flow period is finished, when the teatcups have 'crawled' higher up the teats.

5.5 Eliminate machine stripping from your milking routine

Machine stripping refers to the practice of putting weight on a cluster at the end of milking. This re-opens the connection between the udder cistern and the teat sinus and may result in the removal of a small amount of milk left in the udder cistern.

Published evidence on the relationship between completeness of milking and new mastitis infection rates is conflicting. Most of the older publications reviewed by O'Shea (1987) show that mastitis increased when machine stripping was omitted. In contrast, at least nine studies indicated that small quantities of milk left in the udder did not increase new infection rate or clinical mastitis, and at least three studies found higher levels of infection associated with machine stripping. The latter findings are not surprising. It is likely that the new mastitis infection rate would be increased by vigorous machine stripping which causes sudden air admission into one or more teatcups just before the teatcups are removed.

Extra weights placed on claws affect the balance of a cluster and increase cup slippage which, in turn, increases the risk of mastitis.

Confidence – High

Because machine stripping is a major interruption to the milking routine for little or no benefit, those few cows that require routine machine stripping in any herd should be culled.

Research priority – Low

This issue is not important, especially if pre-milking udder preparation is effective and consistent.

Confidence – High

Attaching clusters: New international and national standards for milklines are based on the principles of fluid dynamics, laboratory research and field experience.

Detaching clusters: The way in which teatcups are removed is often more important than when they are removed.

Research priority – Low

There is little or no effect on mastitis unless overload of milklines increases the frequency of liner slips or teatcup falls.

Technote 25.2 shows nominal pipeline diameters and slopes for dead-end and looped milk lines.

5.6 Allow minimum air to enter cups when attaching clusters

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5.7 Take teatcups off by cutting the vacuum and allowing them to slip free of the teats. Do not break the vacuum at the mouthpiece lip of the liner

Irregular fluctuations in the vacuum of the milking machine (such as a sudden entry of air as clusters are attached, detached or when liners slip) may propel milk droplets towards the teat end with sufficient velocity to partially or totally penetrate the teat duct (Bramley 1992). These 'impacts' may carry bacteria from the surface of the teat into the teat canal beyond the reach of teat disinfectant.

Putting cups on

Excessive air admission, when attaching clusters, may reduce the effective carrying capacity of the milkline. The mechanism that causes 'slug flow' in the milkline is analogous to the 'ripples' and 'waves' that result from a wind gust across a lake surface. A relationship between air admission and the carrying capacity of milklines is acknowledged in new international guideline tables for sizing milklines, where a distinction is made between 'careful' and 'typical' operators (ISO 5707:1996). For simplicity, new Australian Milking Machine Trade Association performance standards and guidelines are based on 'typical' operators only.

Looped milklines can have a higher number of milking units per milkline slope compared with a dead-ended line because the flow-rate of transient air admission per slope is halved (that is, any air admitted can flow to the receiver via two pathways rather than one). For example, current Australian standards suggest a 60 mm looped line at 1.5% slope can have 12 units per slope (24 units on the loop) compared with 9 units for a dead-ended line at the same slope.

Taking cups off

The effect of sudden air admission into the cluster appears to be more critical near the end of milking than at the time of cluster attachment. In experimental studies in the United Kingdom, cows exposed to unstable vacuum conditions around the end of milking had higher new infection rates (Bramley 1992). Rough cup removal increased the new infection rate 3-4 times (National Institute for Research in Dairying unpublished results, 1972). These results imply that bacteria thrown against a weakly-closed teat canal, around the time that the cups are removed, have little or no chance of being flushed from the teat orifice or teat canal by milk flowing from the teat.

5.8 Avoid under and over milking

Under milking

Under milking (or incomplete milking) means that an unacceptable amount of milk is left in the udder after teatcups are removed. Milk left in the ducts or udder cisterns is referred to as 'available milk' or 'strippings'. Milk left in the clusters of secretory cells (alveoli) is referred to as 'residual milk'.

Incomplete milk removal from normal, healthy teats occurs when:

- Teatcups are removed before the last of the available milk drains into the udder cisterns.

Or

- At least one of the four teats moves too deeply into its teatcup ('teatcup crawling'). Teatcup crawling is the more common cause of undermilking. When cup crawl occurs, the milk pathway between the udder cistern and teat sinus becomes blocked near the end of milking.

'Residual milk' cannot be removed by careful machine stripping or hand-stripping without an intramuscular injection of oxytocin. Typically, residual milk may be 1-3 kg or about 10-20% of total milk in the udder. Higher amounts result from incomplete milk ejection associated with poor milking routines, frightened or nervous cows, cows with damaged and scarred teats, cows with sore teats or uncomfortable milking equipment.

Published evidence on the relationship between completeness of milking and new mastitis infection rates is conflicting (as described in section 5.5).

Experiments cited by Dodd and Griffin (1979) dating back to 1936 indicated that lactational yields were reduced by about 3% when 0.5 kg of milk was left in an udder after milking. As a guideline, Mein and Reid (1996) suggested that if milking clusters are correctly designed, well maintained, correctly applied and adjusted, then the mean strippings yield is typically less than 0.25 kg per cow.

Over milking

Over milking defines the period when teatcups remain attached to teats after the milk flow rate from an individual cow has fallen below an arbitrary 'end-point of milking' (a milk flow rate of 400 mL/minute is a commonly accepted end-point for typical herds in Australia and New Zealand).

Some over-milking is inevitable because individual quarters milk out at different times. Both field experience and research herd studies indicate that the effects of a moderate amount of over milking (say 1 or 2 minutes) are relatively minor as long as the milking system is functioning correctly. However, over milking for 5 minutes per cow induced a marked increase in the new infection rate of mastitis in herds when applied in conjunction with pulsation failure (Mein et al 1986).

Regular over milking almost always results in increased thickening of skin at the external teat orifice and increased teat congestion and oedema (Hamann 1987, Hamann et al 1994, Olney and Mitchell 1983). Danish research (Rasmussen 1994) indicated that automatic removal of clusters at a higher end-of-milking threshold (400 versus 200 mL per minute flow-rate) decreased milking time by 0.5 min per cow, improved teat condition and had no influence on milk yield. The incidence and prevalence of subclinical mastitis were not affected but,

Confidence – High

Under milking reduces milk yield, increases the risk of mastitis and may elevate cell counts. There is increasing research and field experiences suggesting that earlier teatcup removal results in improved teat condition.

Research priority – Moderate

Studies of cost-effective ways to reduce overmilking in rotary dairies would be worthwhile.

Technote 6.1 gives guidelines for assessing the completeness of milking.

Technote 6 details how to monitor and maintain milking machine function during lactation.

Revised Technote 9.1 (2003) describes the changes to teats associated with over milking.

Recommended reading

How completely should we aim to empty cows' udders at milking time?

Mein et al 2010.

This article can be found on the Dairy Australia website: www.dairyaustralia.com.au/Farm/Mastitis-and-milk-quality/Lactation/Good-milking-technique.aspx#5.8

The combination of a pre-set maximum milking time and an end-point determined by ACR threshold (whichever comes first) has great potential to shorten milking times per herd by reducing or eliminating the bottlenecks caused by slow-milking cows.

interestingly, significantly fewer cows in the early detachment group developed clinical mastitis.

Field research in the United States (based on the findings of Rasmussen in 1993) has shown that both teat condition and cow behaviour are greatly improved when the end-point flow-rate for automatic cluster removal (ACR) at milking is set at 400 mL/minute or higher, especially in high-producing herds.

Shorter Milking Times

New possibilities for milking herds more quickly with no apparent adverse effects have emerged from Rasmussen's research in conjunction with observations on setting a maximum time limit for milking slow cows (Clarke et al 2004, 2007; Jago et al 2010, Jago et al in press).

The first results from Clarke et al (2004) showed that the use of timed maximum milking durations could save up to 35% of normal milking time of slow milking cows with no adverse effect on their daily milk yield (averaging up to 26 L/d), milk composition, teat condition or cow behaviour. Subsequent studies (Clarke et al 2007) indicated that early termination of milking had no significant effects on incidence of clinical mastitis, sub-clinical mastitis or average ICCC in healthy quarters or in quarters sub-clinically infected with either *Staph aureus* or *Strep uberis* mastitis pathogens (Note: These relationships have not been examined in *Strep agalactiae* herds).

The major practical outcome of these studies has been a marked reduction in the time required to milk herds in which the Shorter Milking Time guidelines are implemented.

The initial goal, set for Australian conditions, has been to remove clusters from about 80% of cows at a flow-rate threshold of 0.4 kg/min while truncating the milking time of the slowest 20% of cows and, thereby, inducing some undermilking in these cows.

Two new studies in New Zealand (Jago et al 2010; Jago et al in press) have confirmed and extended the results of these Australian studies in two major ways. Firstly, the time-saving strategy of truncating the milking of slow cows can be started before cows reach the peak of their lactation. Secondly, further time savings can be achieved when the Shorter Milking Times strategy is applied more aggressively. On average, 30% of cow-milkings were truncated in the NZ study compared with a less aggressive target of 20% in the studies by Clarke et al.

A herd's Maximum Milk-Out Time (MMOT) depends on the average milk production per cow per milking. For example, 80% of cows in a typical Australian herd in which cows are producing an average of 10 L at a single milking will be milked in 6.3 minutes. If MMOT was applied at the suggested target level of 80%, then the slowest 20% of cows in that herd would have their milkings truncated by pulling clusters off after 6.3 minutes. Using a similar target, and assuming that the milking system is functioning correctly, then all cows in herds with an average yield per cow of:

- 12 L/milking will be milked in 7.2 minutes
- 14 L/milking will be milked in 8.0 minutes
- 16 L/milking will be milked in 8.8 minutes

For more information see CowTime's MMOT calculator and Quicknote available on-line at: www.cowtime.com.au.

In practical terms, a fixed time removal of clusters can be difficult to implement (challenging for farmers to measure it, set it and apply it in the shed). A simplified version of MMOT could be applied at the 10-15% level in herringbone dairies. In a 10-a-side, for example, farmers don't need to wait around for the last cow; in a 20-a-side, don't wait for the last 2 or maybe 3 cows, etc. In rotaries, select a platform rotation time and apply a strict policy that 'no cow goes around twice unless there is a specific reason' (e.g. the cluster had been kicked off).

In summary, revised guidelines to avoid under and over milking and to shorten herd milking times are as follows:

- Aim to milk most cows as completely as possible, within a reasonable time, at every milking. This implies a maximum ACR threshold setting of 400 mL/min for herds milked once or twice daily.
- Aim to milk all cows out as evenly as possible. Why? Because uneven milk-out contributes to uneven distribution of milk yield between quarters, leading to less uniform udder conformation which, in turn, reduces the ease and efficiency of machine milking.
- Don't wait around for slow cows to finish milking. Instead, remove clusters from slow-milking cows based on the herd's expected Maximum Milk-Out Time (MMOT), or remove clusters from the last 10-15% of cows milking in any one batch.

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