



# Managing Mastitis

**A practical guide for New Zealand dairy farmers**

3rd Edition





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## Acknowledgements

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Ross Beal, Mel Eden, Ian Gunn, Ian Hook, Jane Lacy-Hulbert, Graham Morris, Gillian Mylrea and Murray Woolford.

### National Mastitis Advisory Committee

The National Mastitis Advisory Committee (NMAC) was established in 1992 to manage the development of the SAMM Plan and its extension to the dairy industry. The committee meets twice a year to discuss progress with mastitis control and review current scientific work in this area. The following people are on the committee (as at March 2001):

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# Introduction

This manual has been written as a resource to inform dairy farmers about mastitis. The emphasis is on a seasonal approach to managing mastitis and includes valuable information and guidelines to assist dairy farmers to control mastitis profitably.

## Why bother about mastitis?

Mastitis is a disease of the udder. A cow with mastitis produces less milk, suffers unnecessary pain and has a shortened productive life. Mastitis can become a herd problem if too many of the cows become infected. The best way to avoid a herd problem is to prevent individual cows from getting mastitis in the first place.

Mastitis milk is less suitable for processing, resulting in reduced product yield and products with poor flavour characteristics and a shortened shelf-life. In addition, contamination of the raw milk supply with the antibiotics used to treat mastitis poses a significant risk to the whole dairy industry.

Because of the considerable economic losses and trade risks associated with mastitis, milk processing companies penalise producers for milk that does not meet the current standards of milk quality, particularly in terms of somatic cell count (SCC) and inhibitory substances.

These standards are based on internationally accepted guidelines and are likely to become more stringent as competition in the market place increases and consumers demand better quality products. For New Zealand to continue producing milk products that attract best prices we must continue to reduce mastitis.

## SAMM Plan – Seasonal Approach to Managing Mastitis

The SAMM Plan provides a logical approach to controlling mastitis on a seasonal basis and was developed in New Zealand to suit our dairying systems. It focuses on six key periods of the seasonal dairy production system and details specific control activities to be implemented in those periods. The SAMM Plan represents an industry consensus as to the best way to control and reduce mastitis levels in New Zealand.

The SAMM Plan objective is 'To produce the world's finest quality milk from cows with healthy udders'.

The measure of success will be a national average bulk milk somatic cell count (BMSCC) below 150,000 cells/ml.

Benefits of reduced mastitis levels include:

- Healthier cows.
- Reduced risk of milk grade penalties based on SCC and antibiotic residues.
- Financial gain from reduced cost of treatment and increased production.
- High quality dairy products that sell for premium prices on the international market.

## SAMM Plan Explanatory Booklet

The *SAMM Plan Explanatory Booklet* is available to dairy farmers through dairy companies or Livestock Improvement. The booklet details the control measures for each period of the dairying year. Used along with accurate records and expert advice it provides a strategy for the prevention and control of mastitis. The SAMM Plan Booklet is updated regularly. Contact your dairy company for the latest version. Further information, supporting the advice given in the SAMM Plan, is published in the *Dairy Exporter* and other media.

### Be on the lookout

Mastitis is a disease found on every dairy farm to a greater or lesser degree. All cows are at risk of developing mastitis. In the same way that humans under stressful situations are more prone to illnesses and infections, a cow's ability to fight infection is affected by her own biology and the environment that she lives in.

Her defence mechanisms may be weakened because of:

- calving
- drying off
- an inadequate diet or mineral deficiencies
- another infection

Changes in her milking routine or other environmental factors can also increase the chances of infection. Check that milking methods, the milking machine and farm races are not exposing cows to unnecessary stress. In other words, look out for the cows' welfare.

### Mastitis targets

To plan a logical prevention programme, you need to know as much as possible about the mastitis situation on your particular farm.

Some useful targets for assessing the mastitis situation in your herd are summarised in the table shown below. Taking control of mastitis requires a good assessment of the current situation before deciding and focusing on particular control strategies.

#### Suggested mastitis targets

<i>Measure</i>	<i>Target</i>
Average BMSCC (cells/ml)	under 200,000
Maximum BMSCC in early lactation (cells/ml)	under 250,000
Maximum BMSCC before drying-off (cells/ml)	under 250,000
Proportion of herd above 150,000 SCC at any herd test	less than 15%
Proportion of heifers above 150,000 SCC at any herd test	less than 10%
Proportion of clinical cows during first 6 weeks of lactation	less than 6.5%
Proportion of clinical cows during rest of lactation (per month)	less than 2.0%
Proportion of clinical cases during the dry period	less than 2.0%
Proportion of herd culled for mastitis related problems	less than 5.0%

(Modified from McDougall & Beal, 2000)

A programme to prevent mastitis involves ongoing support from technical experts, particularly your vet and your milking machine specialist. These people are trained professionals so seeking their advice makes good sense.

## Glossary of abbreviations and terms

**Bacteria/Pathogen** – Bacteria is often used interchangeably with the term pathogen. Bacteria that cause mastitis are divided into two broad categories, major bacteria and minor bacteria. Major bacteria are further divided into cow-associated bacteria (*Staphylococcus aureus* is the most important) and environmental bacteria (*Streptococcus uberis* is the most important). Minor bacteria include the bacteria *Corynebacterium bovis* and Coagulase negative staphylococci.

**Conductivity** – a practical test used to detect mastitis ‘cow-side’. Mastitis increases the salt content of milk, which increases its electrical conductivity. The first foremilk from an individual quarter is drawn into a conductivity meter and a reading generated. By comparing the readings from all 4 quarters of an individual cow, the infected quarter can be identified. Infected quarters are those that differ by more than 15% from the lowest quarter within the cow. Only the first foremilk should be used as this has the highest conductivity, and readings can only be compared within a cow at any one time.

**DCT** – dry cow treatment (sometimes referred to as dry cow therapy). Traditionally this has referred to the treatment of cows with long acting dry cow formulations of intramammary antibiotics, immediately after the last milking of the season. Non-antibiotic alternatives are now available and may be included in this term.

**RMT** – Rapid Mastitis Test – a practical ‘cow-side’ test used to detect mastitis and sometimes known as the Californian Mastitis Test. A small sample of foremilk is drawn onto the test tray and mixed with the RMT detergent solution. The detergent reacts with the somatic cells in the milk, causing the mixture to become thickened. The degree of thickening or gelling is related to the SCC of the milk. This test is only intended for comparing foremilk from different quarters of an individual cow.

**SAMM Plan – Seasonal Approach to Managing Mastitis** – a practical guide to managing mastitis in the seasonal New Zealand dairying situation. The Plan was originally developed by the National Mastitis Advisory Committee and is updated regularly.

**SCC** – Somatic Cell Count – the number of ‘body’ cells counted in a sample of milk. The majority of these somatic or ‘body’ cells are the white blood cells that move into the udder from the blood in response to bacteria entering and infecting the udder.

- **ICSCC** – Individual Cow SCC – this is the SCC of a milk sample collected from an individual cow, such as during herd testing. Typically, a cow with an ICSCC above 150,000 cells/ml (or a heifer with an ICSCC above 120,000 cells/ml) is considered infected.

- **BMSCC** – Bulk Milk SCC – this is the SCC of a representative sample of milk taken from the bulk milk tank. Typically, a herd with a BMSCC above 400,000 cells/ml will attract a milk quality penalty, or be graded, but herds in which mastitis is well controlled will have an average BMSCC below 150,000 cells/ml.

**WHP** – Withholding period – this is the length of time that milk or meat must be withheld from the human food supply chain following calving or the administration of antibiotics or other therapeutics. Rigorous testing of the meat and milk detects residues of a multitude of animal health chemicals and colostrum, and severe penalties can result if withholding periods are not strictly adhered to.



# Mastitis – the disease

Mastitis is an inflammation of the udder. In cows, inflammation of the udder is almost always caused by harmful bacteria, which enter through the teat end and set up infection.

Although a bacterial infection is the root cause, and mastitis or inflammation the effect or outcome, we tend to use the words 'mastitis' and 'infection' interchangeably. This is because preventing mastitis involves preventing bacterial infections.

## Forms of mastitis

Mastitis is seen in various forms or degrees of severity, depending on the type of bacteria causing the infection, the degree of tissue damage and the amount of inflammation generated by the cow's immune system. Mastitis is usually classified according to its visibility to the dairy farmer, ie. clinical or subclinical mastitis. Clinical mastitis can become subclinical if treatment is ineffective, and subclinical mastitis can become clinical at any time. The level at which a subclinical infection becomes clinical can depend on an individual cow or how frequently and closely the milk or the cow is examined for clinical signs.

### Clinical mastitis

Mastitis infections are described as clinical when the changes in the udder and/or the milk are detected easily by the milker, ie. clotting and discoloration of the milk, reddening, heat, pain, swelling and hardening of the udder.

Clinical mastitis can be mild, causing only mild changes in the milk, or severe, where the cow becomes critically ill. Moreover, clinical mastitis may still occur frequently in the herd even though the bulk milk has a low somatic cell count.

The level of clinical infection in a herd can vary widely over the season. Usually clinical mastitis is common in cows during early and late lactation, and in the early dry period.

### Subclinical mastitis

This describes mastitis infections that do not show visible signs, ie. the udder and milk appear normal. Cow-side or laboratory tests (see pages 28-34) are needed to identify the bacteria causing the infection and to show changes in milk composition resulting from mastitis.

Subclinical mastitis can be just as important as clinical mastitis because of the resulting long-term loss in milk production from the infected udder. The farmer may not notice the problem because the milk and udder appear normal.

For every clinical case that is observed, there may be 20-30 subclinical cases of mastitis. In a herd with a BMSCC of 200,000 cells/ml, subclinical mastitis may affect 30 percent of cows in the herd.

It is important to remember that clinical and subclinical mastitis is the same disease. The only difference is often just how hard you look! In many cases, the distinction between clinical and subclinical will be determined by the farmer's power of observation. Some subclinical

infections can flare up, become clinical, and then revert back to the subclinical state without being noticed and without being treated.

## Causes of mastitis

Mastitis is caused almost always by a bacterial infection of the udder, but occasionally mastitis can arise from a traumatic injury of the udder tissue.

To identify the causes of the problem and decide the most effective control strategy, it is helpful to know the bacteria's identity.

Bacteria that are pathogenic (ie. can cause disease) and are capable of infecting the udder fall into two broad categories. These are the major and the minor bacteria and the distinction is related to the difference in severity of mastitis that they cause.

### 1. Major bacteria (pathogens)

These bacteria are capable of causing clinical mastitis, udder tissue damage, and long term or chronic subclinical infections.

The major bacteria can be split into two categories, those that are cow-associated (or contagious), and those which are environmental in origin. In New Zealand, *Staphylococcus aureus* (*Staph. aureus*) is the most important cow-associated bacteria and *Streptococcus uberis* (*Strep. uberis*) is the most important environmental bacteria. Clinical mastitis observed near calving is most often due to *Strep. uberis*, whilst later in the season clinical and subclinical mastitis can be due to *Staph. aureus* or *Strep. uberis*.

#### a) Cow-associated (or contagious) mastitis bacteria

The cow-associated bacteria are *Staph. aureus* and *Strep. agalactiae*, with the latter rarely seen now in New Zealand. These bacteria originate from infected udders within the herd and are usually spread between cows and quarters via residues of infected milk. This milk can be spread from cow to cow at milking time via milkers' hands or teatcup liners, by splashes of contaminated milk during stripping, or by movement of milk between teat cups as the cups are attached or removed from the cow. New infections with cow-associated bacteria can be controlled by good hygiene at milking time, use of post-milking teat sanitation, treating new clinical cases, use of antibiotic dry cow treatment, and culling chronic cases.

In New Zealand, ***Staph. aureus*** is the most significant cow-associated bacteria but in well managed herds the infection rate can be maintained below 5% of cows.

*Staph. aureus* bacteria can invade udder tissues, forming pockets of infection (micro-abscesses) that are difficult to reach with antibiotics. Because infections are difficult to cure, particularly during lactation, prevention is essential. Infections by *Staph. aureus* often result in long term tissue damage, so SCC levels for infected quarters can remain elevated even following a bacteriological cure.

*Staph. aureus* can readily colonise the skin of chapped teats and lesions, and outbreaks are likely to occur if teat damage is a problem.

Mastitis caused by ***Strep. agalactiae*** is highly contagious. Fortunately, this type of mastitis is seldom seen in New Zealand herds and mastitis caused by these bacteria usually responds well to antibiotic treatment.

## b) Environmental mastitis bacteria

The main environmental bacteria are *Strep. uberis*, *Strep. dysgalactiae* and coliforms. As the occurrence of cow-associated mastitis decreases, as it has in recent years, environmental mastitis has increased as the predominant cause of udder health problems.

These bacteria are widespread in a cow's environment and are found in soil and faecal matter and on the cow's skin and hair. Most environmental mastitis cases occur in the period immediately after drying off, before calving and for a few weeks after calving. It has been suggested that a cow's immune system may be suppressed for the first few weeks after calving, which may increase susceptibility to mastitis.

In New Zealand *Strep. uberis* is now the main cause of mastitis. Control measures rely heavily on steps to prevent infections in the dry period and around calving, by use of antibiotics or Teatseal® at drying off, minimising contact with mud and manure, and early detection and treatment of new infections.

Cows with *Strep. uberis* infections can produce milk containing very high numbers of bacteria. It is possible for a cow with an undetected *Strep. uberis* mastitis to cause the bulk milk to be downgraded on a Bactoscan (Standard Plate Count) measurement. However, the normal cause of a Bactoscan grade is poor milking plant hygiene.

Mastitis in early lactation can also be caused by *Strep. dysgalactiae*. This bacteria tends to colonise open wounds at the teat orifice, so teat damage resulting from contamination with sand or grit, or poorly operating milking machines, are prime causes of *Strep. dysgalactiae* outbreaks.

**Coliform mastitis** is rarely subclinical but is usually associated with cows confined indoors. However, the increasing use of feeding and wintering pads in New Zealand may increase the risk of coliform mastitis. Coliform mastitis is usually rapid in onset and shows obvious clinical signs. The cow may also show systemic signs of the disease and have a raised temperature or a reduced appetite. Control depends on minimising contact of the teats with manure.

## 2. Minor bacteria (pathogens)

These bacteria cause less udder damage but cause slight to moderate increases in SCC. While these infections usually remain subclinical, clinical episodes can occur.

In New Zealand the significant minor bacteria are *Corynebacterium bovis* (*C. bovis*) and a group of bacteria known as **Coagulase negative staphylococci (CNS)**. Minor bacteria can be contagious, especially *C. bovis* but can be readily controlled by effective post-milking teat sanitation. There is growing evidence that subclinical infections by either CNS or *C. bovis* may put the udder more at risk of developing an infection by a major bacteria.

The presence of minor bacteria can elevate BMSCC to penalty levels, especially near the end of lactation and usually indicates a breakdown in effective mastitis control procedures such as teat sanitising.

## Occurrence

Knowledge about the occurrence of mastitis bacteria among New Zealand herds is limited. It is based largely on samples collected during field trials, and samples from clinical mastitis cases or outbreaks submitted to laboratories.

### Cows

A study in the Waikato region involving 585 cows across 38 herds in early lactation, found that the average rate of clinical mastitis was 10% of cows. However, the range was from 1 to 22% (McDougall, 1999).

### Heifers

A study of mastitis in first lactation heifers in New Zealand examined the bacteriology for 458 heifers across 11 Waikato herds at calving and then again at drying off (Pankey et al., 1996). Overall 32% of heifers were found to be subclinically infected with one of the important mastitis-causing bacteria, including 12% with *Strep. uberis*. A total of 8.1% of heifers developed clinical mastitis at calving and the range across herds was 0-21%.

This study showed a decline in the level of environmental streptococcal infections over the lactation (from 12.2% to 2.8%) and an increase in the level of infections by *C. bovis* (from 0% to 43%) and *Staph. aureus* (from 0.9% to 2.8%). There was a wide variation across farms.

### Summary

The majority of intramammary infections in New Zealand are attributable to two major bacteria, *Strep. uberis* and *Staph. aureus*.

*Strep. uberis* appears to be the most common bacteria associated with clinical mastitis at all stages of lactation, although mastitis caused by this bacteria generally declines as lactation advances. The occurrence of clinical mastitis due to *Staph. aureus* varies between herds but is generally low. CNS are relatively common causes of both clinical and subclinical mastitis throughout lactation. Infections by *C. bovis* are common in late lactation, often associated with poor teat spraying technique. Coliforms, *Strep. dysgalactiae* and *Strep. agalactiae* appear to be relatively uncommon causes of mastitis in well-managed herds in New Zealand. Profiles for the common mastitis bacteria in New Zealand are shown in the table on the next page.

## Profiles of the mastitis bacteria in New Zealand

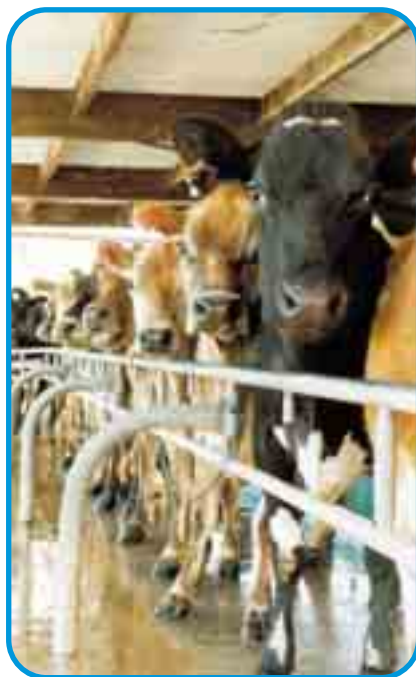
<b>Bacteria</b>	<b>Risk periods</b>	<b>Causes significant increase in SCC</b>	<b>Causes clinical mastitis</b>	<b>Comments</b>
<i>Staph. aureus</i>	throughout lactation	yes	yes	significant impact on long term production
<i>Strep. agalactiae</i>	throughout lactation	yes	yes	uncommon
<i>Strep. uberis</i>	dry period and early lactation	yes	typically 50% will go clinical	major effect on early season SCC
<i>Strep. dysgalactiae</i>	dry period and early lactation	yes	yes	comprises 10-15% of all Strep. isolates
Coag. negative staphs.	throughout lactation	no	not usually	at high levels can increase BMSCC
<i>C. bovis</i>	throughout lactation	no	not usually	associated with ineffective teat spraying

(modified from Woolford, 1997)

## Breeding for resistance

It is possible that progress could be made by breeding cows that are more resistant to mastitis. Previous selections for increased milk production may have inadvertently selected for a higher susceptibility to mastitis since some favoured traits, such as fast milking speed, are a risk factor for mastitis.

Improving mastitis resistance by breeding will be a complex step. The connection between mastitis resistance and factors such as size and shape of the teat and teat orifice, and effectiveness of the immune system, are still not fully understood, making the selection process very difficult. But breeding programmes are now in progress which incorporate certain aspects of a cow's mastitis history and over time, these should highlight the inheritable factors for mastitis resistance.



# Effects of mastitis

## Cost of mastitis

Mastitis is of major economic importance to the New Zealand dairy industry, both at the farm level and at the processing and marketing level.

At the farm level, the cost of mastitis can be significant due to loss of production, discarded milk, the cost of treatment, deaths from mastitis, milk quality penalties, time, stress on the farmer, replacement costs and premature culling.

The annual cost of mastitis in a New Zealand herd will vary according to the level of clinical and subclinical mastitis. But an average sized herd with a seasonal average BMSCC of 250,000 cells/ml is likely to be losing approximately \$6000 per year.

The National Mastitis Advisory Committee has set a target of 150,000 cells/ml for the seasonal average BMSCC and suggests that it makes economic sense for all herds to get to this level. At this level it is unlikely a herd will incur SCC penalties.

## Effect on production

There has been much research conducted overseas on the effect of mastitis on production. Volume of production losses over the entire lactation averaged 6.9% (range from 3.5% to 11.2%), following cases of clinical mastitis. How relevant this data is to New Zealand is not known. Historical research at Ruakura in New Zealand showed that quarters subclinically infected with *Staph. aureus* both in mature cows and in first lactation heifers yielded less milk and milkfat than did uninfected quarters (Woolford et al., 1984).

## Heifers

In first lactation heifers, chronic subclinical infections resulted in significant yield losses (7.8%) over their first lactation when compared to their uninfected twin sisters. Despite having been cured of the infection before the start of the second lactation, these heifers continued to show significant yield losses (8.4%) in the subsequent lactation. This suggests that heifers developing mastitis in their first lactation suffer lasting damage to the udder tissue and a lifetime reduction in milk production.

## Older cows

Older cows in the same experiment were able to compensate to a major extent for the yield loss in their infected quarters. Milk production in the uninfected quarters increased, resulting in a very small net loss in milk production. In addition, quarters that were cured of the infection recovered their productive capacity in the following lactation.

These results emphasise the importance of early detection and treatment of clinical mastitis, especially for heifers, if production losses are to be minimised.

Subclinically infected cows (ie. high SCC cows) produce less milk than those with low SCC. Data from the USA suggest that for each increase in BMSCC of 100,000 cells/ml there is a 1.5% to 3% decrease in herd production (Radostits et al., 1996). Early New Zealand work indicated that volume losses of 5.5% and milk fat losses of 2.0% were incurred by cows with an average SCC between 250-750,000 cells/ml compared to cows with an average seasonal SCC below 250,000 cells/ml (Macmillan et al., 1983).

Taken together these studies emphasise the need for mastitis prevention measures for all animals in the herd if production losses are to be minimised.

## Loss in product quantity and quality

At the processing and marketing level, mastitis affects the yields of certain products, their keeping quality, taste and general performance. For example, reducing the SCC from 1,000,000 cells/ml to below 400,000 cells/ml can increase cheese yields by over 4%, with further increases possible if the SCC is reduced to around 100,000 cells/ml.

A cow with mastitis not only produces milk with more somatic cells, she also produces milk containing less casein, less fat, more whey proteins, more salt and more damaging enzymes. All of these factors reduce product quantity and quality. In the near future, payment schemes for milk may better reflect its valuable components. Since casein protein is valuable, and whey protein is less valuable, there may be more incentive to reduce SCC in order to maximise the milk cheque.

## Effect at farm level

Dairy processors apply financial penalties for sub-standard or poor quality milk and each case of mastitis puts the farmer at risk of incurring these penalties.

Milk quality is affected by mastitis in three ways:

- a) Somatic cells (measured by bulk milk somatic cell counts)
- b) Inhibitory substances (measured by laboratory tests)
- c) Bacteria (measured by Bactoscan)

### a) Bulk milk somatic cell counts (BMSCC)

All milk processing companies test regularly for BMSCC, although penalty levels may vary. Most herds are now tested for somatic cell count levels for each milk consignment.

The maximum for most New Zealand dairy companies is currently 400,000 cells/ml, which is similar to that set by the European Community and other competitor countries. The New Zealand dairy industry must keep ahead of these standards.

Accordingly, the National Mastitis Advisory Committee has set their objective 'To produce the world's finest quality milk from cows with healthy udders'. The measure of success will be a national average BMSCC of below 150,000 cells/ml.

## b) Inhibitory substances

The presence of antibiotics in milk is a major manufacturing problem because of the adverse effect on the starter cultures used in many manufacturing processes. Food safety is of increasing importance, with many customers world-wide expecting food processing companies to produce safe, healthy food, free from bacteria and antibiotic residues. In addition to this, export markets on which the dairy industry is highly dependent may refuse to accept dairy products from New Zealand if inhibitory substances are detected. The penalties for antibiotic contamination are therefore heavy, reflecting this risk.

A survey conducted by a milk processing company showed that the majority of cases where penalties were incurred were due to milking treated cows into the bulk milk tank before the completion of the recommended withholding time for the product used.

It is recommended that antibiotic treated mastitis cows be run separate from the main herd. They must be milked last, and after the milk delivery line has been removed from the bulk milk tank. Also, it is a requirement that treated animals must be clearly identified and records kept.

When run as a separate group, treated cows can also be given the extra attention needed to achieve the best possible cure rates for mastitis.

## c) Bactoscan (or Standard Plate Count)

Bactoscan assesses the number of bacteria in milk, not the number of somatic cells in milk.

Mastitis bacteria (streptococci in particular) can give rise to some bacterial problems, but most bacterial grades are caused by problems with milking plant hygiene.



# Somatic cells

## Function in the udder

The somatic cells found in milk are part of the cow's natural defence system and should not be confused with bacteria – the cause of an infection.

The somatic cells found in milk are 'body cells'. Somatic cells are made up of a combination of white blood cells and epithelial cells. White blood cells enter the milk from the bloodstream in response to inflammation and try to destroy the bacteria responsible for infection. White blood cells make up 98% of the somatic cells. Epithelial cells are shed from the lining of the udder tissue and make up about 2% of somatic cells.

The somatic cells come into the udder to fight and get rid of the bacteria that manage to enter the udder through the teat canal. The somatic cells are the cow's second line of defence, after the teat canal, and they try to prevent bacteria infecting and damaging the udder tissue. Somatic cells are not always effective against bacteria – some bacteria are very hard to kill – and hence our dependence on antibiotics to control many infections.

## Normal levels

Somatic cells are always present in the milk, as a protection for the cow against mastitis infections. Most cows that are free from mastitis and have had no previous infections would be expected to have a somatic cell count (SCC) below 100,000 cells/ml, with many below 50,000 cells/ml, and some below 10,000 cells/ml. Somatic cell counts are usually measured in thousands of cells/ml (see *Somatic Cell Count Report* below). Variation will occur between herds with different mastitis histories.

**LIVESTOCK IMPROVEMENT SOMATIC CELL COUNT REPORT**

PASTORAL FARMS  
C/- LIVESTOCK IMPROVEMENT  
PRIVATE BAG 3918  
HAMILTON

Latest Test Order

HERD AVERAGES AS AT 18/12/2006  
ANCESTRY: 56% SW 82/82 PW 14/78

TEST DATE: 12/12/2006  
DATE: 18/12/2006

COW DETAILS	Current Lactation Average	HERD AVERAGES AS AT 18/12/2006										Previous Lactation Average	Comments
		DEC 1999	DEC 2000	JAN 2000	MAR 2000	MAY 2000	SEP 2000	NOV 2000	DEC 2000	DEC 2001	DEC 2002		
11	86/32	245/10	174	298	427	288	219	213	288	1380			
21	11	2/82	407/4	341	457	302	581	104	182	1461	1118		
44	2	133/50	416/4					205	282	528	957		
53	2	8/51	195/4					36	82	288	840		
218	6	130/78	207/4	67	71	80	214	131	44	582	877	82/8	

**Somatic cell counts are usually measured in thousands of cell/ml. (The January count for cow No.11 is 427,000 cells/ml.)**

## Effect of mastitis on SCC

The somatic cell count is usually the first reliable indicator of a mastitis infection. If the udder becomes infected, the SCC goes up significantly. The rise in cell numbers following an infection can be very rapid – increasing by 100-fold within six hours.

Some mastitis-causing bacteria stimulate the release of millions of somatic cells within a few hours of infection occurring, others may stimulate the release of only a few thousand. Large variations in SCC occur between cows dealing with a clinical or a subclinical mastitis infection, and large fluctuations occur within a cow as she deals with the mastitis over a period of time.

Individual cow somatic cell count (ICSCC) levels above 150,000 cells/ml for cows and 120,000 cells/ml for heifers are the accepted thresholds that indicate the presence of an infection.

## Other factors can affect SCC

A number of other factors may affect the ICSCC.

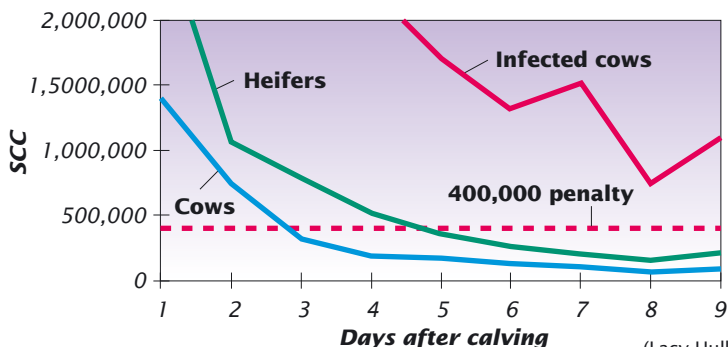
### a) Colostrum

This contains very high numbers of somatic cells. Results from Dairying Research Corporation research showed that uninfected cows calved down with an average SCC of 1.5 million cells/ml and heifers at 3 million cells/ml (see graph below). This is a normal process in the udder in the transition to milk production and does not indicate the presence of mastitis.

With twice daily machine milking, average SCC drops below the 400,000 cells/ml penalty threshold by day 4 for cows, and day 5 for heifers. This confirms that milk should be withheld from the bulk milk tank for 4 days (eight milkings) and 5 days (10 milkings) after calving for cows and heifers respectively. Therefore, make sure that fail-safe systems are in place to prevent this milk entering the bulk milk tank.

Cows with mastitis have much higher SCC than cows without mastitis, and the same is true in the colostrum period. Infection causes an additional increase in SCC over and above normal levels (see graph below). Look for mastitis whilst cows are still in the colostrum mob to avoid penalties for SCC when they join the milking herd.

### Reduction in average SCC after calving for colostrum cows, heifers, and infected cows



(Lacy-Hulbert, 1999)

## b) End of season production

Towards the end of the season, ICSCC can be increased by factors other than infection. In some cows near drying off, milk yields drop so low that a more rapid rate of udder involution (ie. going dry) is triggered. When the herd average yield drops below 10 litres/cow/day there is an increased risk of BMSCC grades, due to the presence of low producing cows in the herd undergoing udder involution. Even cows that are uninfected will start to produce milk with a very high SCC when their milk yield drops below about 5 litres/day.

## c) Every-other-day milking

This is sometimes called 'skip-a-day' milking. When used for a short period before drying off, it will cause a significant increase in cow SCC, so is a strategy that the SAMM Plan advises against. By comparison, once-a-day milking prior to drying off has minimal effect on SCC levels in uninfected cows.

## d) Once-a-day milking

Switching to once-a-day milking can cause the SCC of cows with clinical or subclinical mastitis to increase dramatically for a short period of time and then subside as the cow's immune systems adjusts. To avoid grading for BMSCC, dry off or withhold milk from clinical or subclinical cows before switching to once-a-day milking. Once-a-day milking should not cause any significant long term increase in SCC in uninfected cows.

## e) Age

SCC tends to be higher in older cows, even in the absence of mastitis. This may be due to the tissue damage caused by past infections or to increased shedding of the epithelial cells.

## f) 'Stress'

Disruptions to the normal routine, such as bulling activity, artificial insemination, pregnancy testing, stray voltage, or under-feeding may cause short-term rises in SCC. Any upsets in the normal milking routine can cause cows to withhold their milk for one or more milkings, resulting in a higher SCC when they start milking again properly. Changes in SCC due to 'stress' are usually much more marked in cows with clinical or subclinical mastitis.

# Avoiding BMSCC penalties

## Measure SCC during lactation

At least four herd tests during lactation are recommended for reliable results. However, one, two or three herd tests are better than none, especially if used for specific treatment purposes.

If done regularly throughout the season, the ICSCC gives a picture of the new infection rate. Regular tests also help you to monitor the effectiveness of treatments during lactation.

Tests should be spread from three weeks after calving to just prior to drying off. A herd test late in lactation can be used to identify low yielding cows and high SCC cows. It is important to conduct the last herd test of the season within 4-6 weeks of drying off to correctly identify cows for drying off treatments (ie. antibiotics or Teatseal®).

In every herd in every year some cows will have subclinical mastitis which could go undetected. If these cows are identified and treated with dry cow preparations at the end of lactation, or culled, the number of chronic infections carried over into the next season will be reduced. Regular testing is also a very useful way to monitor the herd mastitis level, and to give early warning of a deterioration. So test at regular intervals, every year.

### **Reduce the number of cows with high ICSCC**

A quick remedy involves identifying offending cows and keeping their milk out of the bulk milk tank.

In one herd study, 4% of the cows produced 50% of the somatic cells but only 5% of the milk. To remedy a grading situation and reduce the BMSCC, only a few cows may need to be removed from the milking herd. This removal may be short-term, with cows re-introduced to the herd as mastitis infections are cured and SCC is lowered.

In severe cases, a quarter may need to be dried off, or the cow removed from the main herd and used for calf rearing, or culled.

Near the end of lactation, low producing cows (less than 5 litres per day) and high SCC cows should be dried off earlier than the main herd.

### **Identify persistently high SCC cows**

Cows with high cell counts are those with severe infections. They are likely to be shedding large numbers of bacteria and are therefore a source of infection for the rest of the herd.

Expert opinions differ on the best action to take with these persistently high SCC cows. One must be realistic and look at the economics of a particular case before automatically deciding to get rid of them. Cows with persistently high SCC, even after dry cow treatment, should be prime candidates for culling.

For cows having only a single quarter infected, it may be practical to dry off the infected quarter and rely on the compensatory effect to keep milk production near normal from those animals.

You should also look critically at the new infection rate. If it remains low, then the high SCC cows are not much of a problem and will depart the herd eventually anyway. *If the new infection rate is high, look for the cause.*

Meantime continue to check the milking machine regularly and carefully apply all other mastitis control measures detailed in the SAMM Plan.

# Recording cow SCC

Livestock Improvement MINDA herd management reports include SCC results.

If your herd is registered for somatic cell counting, cell count information will appear on the MINDA *Herd Test Report*, the *Somatic Cell Count Report* and a number of other reports, including the *Culling Guide* and the *Individual Animal History*.

During the 1998/99 season the National Milk Analysis Centre in Hamilton processed 9,708,526 samples from 11,850 herds for individual cow somatic cell counts.

## 1. Herd Test Report

The standard *Herd Test Report* lists the production and SCC results for cows for the latest herd test. Detailed SCC information is shown under the 'Somatic Cell Count Trends'.

Detailed SCC information is shown under the 'Somatic Cell Count Trends' as part of the Herd Test Report.

LIVESTOCK IMPROVEMENT		HERD TEST SUMMARY		MINDA								
NATIONAL MILK ANALYSIS CENTRE 120 HAMILTON RD HAMILTON ONT L8M 1G8 TEL: (905) 571-1234 FAX: (905) 571-1234		HERD NO. 12345678 TEST DATE: 12/01/99		MINDA REPORT NO. 12345678 TEST DATE: 12/01/99								
Somatic Cell Count Trends												
All Cows												
Cell Count Range (000)	OCT 1998		DEC 1998		APR 1999		AUG 1999		DEC 1999		APR 2000	
0-100	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
100-200	20	14	24	19	30	22	35	27	40	32	45	35
200-400	15	11	18	14	22	17	25	20	30	24	35	28
400+	5	4	7	5	10	8	15	12	20	16	25	20
Total Cows	140		125		132		135		150		165	
All Bulk Cows	120		105		110		115		125		135	
Two Year Olds												
Cell Count Range (000)	OCT 1998		DEC 1998		APR 1999		AUG 1999		DEC 1999		APR 2000	
0-100	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
100-200	10	10	12	12	15	15	18	18	22	22	25	25
200-400	5	5	6	6	8	8	10	10	12	12	15	15
400+	2	2	3	3	4	4	5	5	6	6	8	8
Total Cows	17		21		27		33		40		48	
All Bulk Cows	15		18		22		27		32		38	
Likely Infection Rate												
Comparison of likely infection rate between consecutive tests with animals present at BOTH TESTS ONLY												
TOTAL COWS COMPARED = 140		LIKELY INFECTION STATUS										
DATE OF TEST		% OF ANIMALS LIKELY INFECTED						NUMBER OF ANIMALS LIKELY INFECTED				
08 NOVEMBER 1998		18%						25				
02 DECEMBER 1998		21%						30				
Highest SCC Cows at Latest Test (over 50)												
Cow No.	Cell Count	Cow No.	Cell Count	Cow No.	Cell Count	Cow No.	Cell Count	Cow No.	Cell Count	Cow No.	Cell Count	
15	1500	118	500	58	300	112	100	210	150			
25	1110	100	400	50	200	80	170	50	120			
40	800	100	300	30	150	100	150					
30	440	8	100	40	100	30	100					
210	370	140	100	10	100	100	100					
27	400	81	100	10	100	100	100					
100	400	60	100	100	210	100	100					
140	400	80	100	17	100	10	100					
120	300	30	100	100	100	100	100					
120	100	50	100	70	100	100	100					

## Somatic Cell Count Trends

The 'Somatic Cell Count Trends' (see page 21) which is part of the *Herd Test Report* has four tables:

### All Cows

Sorts the whole herd (including two year-olds) into four cell count ranges and calculates the percentage of animals in each category. Up to eight test results can be included and a bulk cell count is estimated for each herd test.

### Two Year Olds

Data for two year-old cows are separated from the rest of the herd in a similar format to the 'All Cows' table so that the overall trend for the heifer group can be looked at separately.

With some exceptions, the two year-olds enter the herd as uninfected animals so their SCC should be in the lowest range. Ideally they should remain low for the whole of the season. If the SCC for two year-olds move into the higher cell count ranges, and the estimated bulk count increases, it suggests that mastitis is being spread from other cows in the herd, and that the mastitis control procedures to prevent cow-associated mastitis are not working as well as they should be.

Surveys in recent seasons have confirmed that a high proportion of low cell count herds have over 90% of the two year-olds in the lowest cell count range right throughout the season. However, in a high proportion of high cell count herds there is a steady deterioration in the two year-old group with a tendency for the bulk counts of all cows and the two year-olds to become very similar by the end of the season.

### Likely Infection Rate

The 'Likely Infection Rate' table on the report compares the likely infection rate between consecutive tests of animals present at both tests.

Studies at Massey University showed that cows that have a ICSCC above 150,000 cells/ml and any heifers above 120,000 cells/ml have a 90% chance of being infected with mastitis-causing bacteria. The likely infection status is based on these thresholds.

### Highest SCC Cows at Latest Test

This table shows the cow number and cell count for up to 60 cows that have exceeded threshold SCC levels at the latest test.

## 2. Somatic Cell Count Report

The *Somatic Cell Count Report* is an optional report (see example below) that shows cow age, production worth (PW), current lactation average cell count (after three tests) and individual test cell counts (eight counts in total). The comment column is available for farmers to add other information.

**LIVESTOCK IMPROVEMENT**  
PASTORAL FARMS  
C/LIVESTOCK IMPROVEMENT  
PRIVATE BAG 3916  
HAMILTON

**SOMATIC CELL COUNT REPORT**  
Latest Test Order

HERD AVERAGES AS AT 18/12/2008  
ANCESTRY: 54% BW: 62/52 PW: 74/75

TEST DATE: 12/12/2008  
DATE: 18/12/2008

DDMP: 17/156  
N905-625-9927 1  
PAGE: 1

COW DETAILS		Current Lactation Average	OCT 1999 Count (000)	DEC 1999 Count (000)	JAN 2000 Count (000)	MAR 2000 Count (000)	AUG 2000 Count (000)	SEP 2000 Count (000)	NOV 2000 Count (000)	DEC 2000 Count (000)	Previous Lactation Average	Comments
11	8	86/92	245/3	174	299	427	388	219	213	286	1390	
21	11	282	407/4	241	457	307	581	104	182	1461	1118	
44	2	130/50	416/4					205	288	528	957	234/6
53	2	6/51	150/4					36	67	268	840	
218	8	130/78	203/4	67	73	89	216	121	44	552	577	82/6

Part of Somatic Cell Count Report

Recently calved cows often have relatively high cell counts that may not indicate mastitis, so tests within ten days of calving are highlighted for easy recognition.

The previous and current lactation average cell counts are a geometric mean and not a simple average. A geometric mean adjusts the average to reduce the influence of a single very high or very low cell count. Because it is an average figure, at least three tests have to be completed before a calculation is made.

The *Somatic Cell Count Report* can be ordered in Latest Test Order, Test Number Order or Lactation Average Order.

All the information included in the standard format is shown so that it is very easy to see the ages, PWs, or the previous year's average cell count for the cows in each part of the cell count range.

Other reports that also show SCC information include:

## 3. Culling Guide

The *Culling Guide* shows up to 10% of your worst cows based on average SCC, if above 500,000 cells/ml. You can use this information alongside your records on clinical mastitis (and with other production data) when you are making culling decisions.

## 4. Individual Animal History Reports

Cell count information is reproduced in *Individual Animal History* reports. Having a low SCC herd can be an important factor when you are selling cows for dairying purposes. Recent evidence suggests that cows with complete histories including a low SCC will sell for premium prices compared with cows where this history is lacking.

### SCC and BMSCC

The dairy company BMSCC is a true measure of the SCC of the herd's milk received at the factory.

The Livestock Improvement estimated BMSCC is a calculation based on individual cow SCC, adjusted for volume of milk produced by that cow on that day, and of the cows tested on that day. It is very difficult to accurately measure the SCC of very high cow SCC samples so these samples can sometimes be underestimated.

The company figure is a more accurate reflection of the BMSCC but when measured on the same day, the two figures should be reasonably close. The degree of matching depends on the number of cows in the herd with a very high SCC and the number of infected cows that are not having their milk go into the milk tank because they are under antibiotic treatment or milk withholding.



*Sample collecting for herd testing*

# Detection of mastitis

## Early detection is best

The earlier a mastitis infection is found and treated the more likely the quarter will be cured. If mastitis infections become established the cow is more likely to have permanent damage to the quarter, lose production as a result and be a major source of infection for other cows.

## Detection at herd level

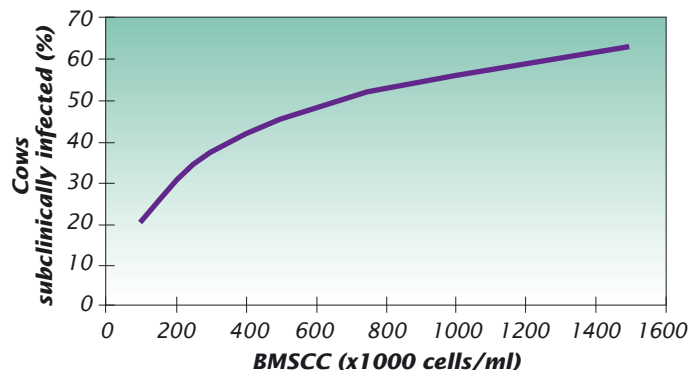
### 1. Monitor BMSCC

Levels of mastitis infection for a particular herd cannot be gauged with any accuracy without examining milk from every quarter and every cow. The average bulk milk somatic cell count (BMSCC) can however, give a general indication of the level of subclinical infection within a herd. The BMSCC is a measure of the concentration of somatic cells in milk from all cows going into the bulk milk tank. It is an indirect way of estimating the level of subclinical mastitis in the herd.

The percentage of cows infected with a major bacteria can be estimated from the BMSCC (see graph below). Extrapolating from a New Zealand study (Holdaway, 1990):

- a BMSCC of 100,000 cells/ml indicates that approx. 20% of cows are subclinically infected
- a BMSCC of 200,000 cells/ml indicates that approx. 30% of cows are subclinically infected
- a BMSCC of 300,000 cells/ml indicates that approx. 40% of cows are subclinically infected.

### Percent of cows subclinically infected compared with the BMSCC



(Derived from Holdaway, 1990)

A series of BMSCC for a herd should be assessed to see both the level and trend for subclinical infections.

When the BMSCC is below approximately 100-150,000 cells/ml, the onset of new mastitis infections is often indicated by day to day increases in the BMSCC. However, in herds having higher BMSCC levels, the somatic

cell contribution from infected cows varies widely from day to day, making it impossible to differentiate the individual new infections. For example, in a herd that trends along at about 70,000 cells/ml, an abrupt increase of 20-30,000 almost certainly means that a new infection has developed and should be looked for. Compare that to a herd with a normal level of 200,000 cells/ml in which the BMSCC frequently fluctuates by over 50,000-70,000. In that herd, an increase to 250,000 cells/ml is essentially meaningless.

## 2. Check the milk filter

Checking for changes on the milk filter after every milking is another important way to monitor the herd mastitis status. If there are any clots on the filter, perform a close examination of the cows at the subsequent milking. Look for new clinical infections by stripping and examining foremilk before applying the teat-cups. Suspect cows can be withheld from the next milking and the filter re-checked until the clots disappear. Target known high somatic cell count (SCC) cows first, then heifers, and then older cows. Alternatively, check rear quarters first, since these are more susceptible to mastitis than front quarters. Keep checking the cows until the source of the clots has been found.

## Detection of individual cows

### 1. Clinical mastitis

Early detection of clinical cases of mastitis allows prompt treatment. This not only results in higher cure rates, but it reduces the risk of infection being passed to other cows, and the development of chronic infections. The most reliable way to find clinical infections is to squirt milk from an un milked quarter on to a dark surface or a container, eg. a Rapid Mastitis Test tray. Milk should not be stripped into the hand as this aids in the spread of infection.

Look for abnormal milk that persists for more than 3 squirts of milk. The milk may be clotted, stringy or contain flakes, or be watery or brownish in colour. The appearance of the milk changes with the type of inflammatory response. Compare milk from different quarters to pick up any discolouration – sometimes it may be the only sign of an infection.

If you're not sure about the significance of what you are seeing, ask yourself if you would drink it. The golden rule is, **'If you wouldn't drink it, don't put it in the bulk milk tank'**.

Taking a squirt from each quarter is time consuming and exhausting so be on the constant lookout for udders that are hot, swollen and painful, or not milking out properly. Swelling due to mastitis is particularly noticeable after milking. Feel the udder as the cups are removed for heat, swelling or unevenness. This only takes a couple of seconds but gives a valuable early warning of an infection.

If the milker knows the cows, the first warning may be a change in behaviour or the cow appearing to be lame. The cow may be slow out of the paddock, may walk slowly behind her usual herd position up the farm race, be late in to milk, or simply look sick.

When clots appear on the filter and mastitis is not a widespread problem, focus first on the 'suspect cows' (eg. cows that have not milked out, cows that have recently had mastitis, or cows with a high individual cow

SCC at the last herd test). Cows with teat damage should be checked frequently by stripping the milk.

It is not possible to be sure which type of bacteria is causing the mastitis by visual examination of the milk. To identify the bacteria involved, milk samples must be collected and submitted for bacterial culture.

(See page 32).



***The golden rule is,  
'If you wouldn't drink  
it, don't put in the bulk  
milk tank'***

## 2. Subclinical mastitis

By definition, subclinical mastitis cannot be detected by visual assessment of the milk. Instead, special cow-side or laboratory tests are required to detect the more subtle changes in milk and identify the infected cows. It is not necessary to immediately treat these infections – it is sufficient to identify these cows and use this information in future management decisions.

## Detection in the colostrum mob

Dairying Research Corporation field trials found that on average, 8.5% of cows in a herd developed clinical mastitis within one month of calving – of those cases, 75% were detected when cows were in the colostrum mob. Careful colostrum mob management is an efficient and successful way of reducing BMSCC and clinical mastitis in the herd.

### How to manage the colostrum mob

- Identify and treat clinical cases – check all newly calved cows for clinical mastitis by examining foremilk before each milking. Treat clinical cases immediately to improve the speed and chances of a cure.
- Identify and record subclinically infected quarters – a check for subclinical mastitis aids the detection process and provides an early alert to new infections.

After 8 full milkings for cows, and 10 full milkings for heifers, all animals should be tested for subclinical mastitis before being milked into the bulk milk tank. Subclinical infections can be identified using a Rapid Mastitis Test or a conductivity meter.



**Those quarters still showing a strong positive subclinical mastitis test reaction after eight milkings (cows) and 10 milkings (heifers) are highly likely to be infected with a major mastitis bacteria.**

These cases should be recorded and monitored and treated if the infection worsens or if the herd is facing a grading situation. If there are no other signs of clinical mastitis in the positive quarters (based on RMT or conductivity meter) you may decide not to treat, but simply keep the cows in the colostrum mob for another 24 hours before re-testing them. If infected cows are put into the supply herd they will increase the BMSCC, and may increase the likelihood of infection being passed to other cows. Discuss treatment options with your vet, and develop a management policy for your farm that all staff understand and follow.

### Additional tests for detecting mastitis

Various tests can be applied to milk to detect the presence of mastitis. Some tests are suitable for use in the farm dairy, ie. cow-side, whilst others can only be performed in the laboratory.

#### 1. Cow-side tests

Cow-side tests include the Rapid Mastitis Test (also called the Californian Mastitis Test) and conductivity meters. These tests are quick and easy, they show which quarter/s is/are infected but require some experience for a correct interpretation.

### a) Rapid Mastitis Test (RMT)

Inflammation of the udder causes massive numbers of white blood cells to move into the milk in an attempt to control the infection by killing the bacteria. These white blood cells, together with a smaller number of damaged udder cells make up the somatic cells of the milk, thus the SCC increases in cows with mastitis.

The RMT estimates the SCC of milk by measuring the degree of thickening when a reagent is added to the milk sample.

### How to do a Rapid Mastitis Test

1. Discard the very first squirt of foremilk.
2. Squirt milk from each quarter into a different well on the RMT test tray (approximately 2 ml from each quarter).
3. Mix each milk sample with an equal volume of reagent (prepared reagents are available commercially).
4. Swirl the mixture vigorously and assess the degree of gelling in each sample (thickening may be more visible if the test tray is tilted).



The reagent ruptures the somatic cells and causes them to thicken into a gel. The degree of gelling or thickening is related to the number of cells present. The thicker the gel, the greater the number of cells and the worse the infection. The tables below compare different gel scoring systems with the corresponding average SCC in the milk, and give a simplified scoring system.

Ideally the test should be conducted on all four quarters of a cow and the gelling compared between quarters. This improves detection and interpretation of a mild reaction.

### Scoring system for the gel reaction in an RMT and the corresponding average SCC in milk

Score	Gelling	SCC (x 1000 cells/ml)
Negative (N)	None	100
Trace (T)	Slight	300
1	Slight to moderate	900
2	Moderate	2700
3	Heavy	8100

(Philpot & Nickerson, 1991)

### Simplified scoring system for the RMT

Score	Gelling
N = Negative	None
S = Suspicious	Some
P = Positive	Distinct

The test is simple, quick and relatively easy to do, but detection and interpretation of the gel formation is highly subjective (ie. depends on the judgement and experience of the operator). Results can also be affected by other factors. For example, colostrum contains very high numbers of somatic cells, which can cause mild gel reactions, whereas milk from an infected quarter will create a very thick, almost solid gel. Look for the very definite reactions when testing cows within a few days of calving.

In very late lactation, low milk volumes and the natural drying off process can also increase the cow's SCC, so once again, only interpret the very definite thick gel reactions as mastitis.

## b) Conductivity meters

When udder tissue is infected, damage to the blood-milk barrier results in salt from the blood leaking into the milk. This causes an increase in ionic strength of the milk and hence a higher conductivity. Electrical conductivity of the milk can be detected by using a conductivity meter. Meters are used to find quarters with subclinical infections or very early clinical cases before the milk changes become visible.

Conductivity is best determined in the morning, when there is a lower fat test, and therefore higher milk conductivity.

### How to use the conductivity meter

**Note:** Only the first foremilk should be used as this milk has the highest conductivity.

1. Squirt milk into the meter.
2. Record conductivity.
3. Discard milk sample.
4. Repeat for all quarters of the **same** cow.



Conductivity varies widely between different cows but is very similar between quarters within a cow. Therefore to detect mastitis, the conductivity of the foremilk must be compared between quarters of the same cow and should not be compared between cows.

In the same cow, quarters with a conductivity reading that differs by more than 15% compared to the lowest reading quarter have a high probability of being infected.

Some hand-held meters will store the 4 readings for a particular cow and generate a 'difference' value. This is the difference between a particular reading and the lowest of the 4 readings. Interpret a difference of greater than 1 or 2 as an indication of mastitis.

Infected quarters can be detected in the colostrum period using conductivity but are best undertaken after the fourth milking. Conductivity meters will detect infected quarters throughout the entire lactation period.

## 2. Laboratory tests

### a) Somatic cell count

One of the best laboratory methods for detecting mastitis is the individual cow somatic cell count (ICSCC). SCC testing can be carried out periodically during the season, using automated equipment that makes the testing simple, rapid and relatively inexpensive. The milk samples collected for herd testing are used for this test.

SCC is measured using a Fossomatic automated counter, whereby the nuclei of each cell is stained with a fluorescent marker and counted electronically. This count is normally undertaken on the composite milk, bulked from all quarters of the cow. The SCC is counted in thousands of cells per millilitre of milk and can be reported on an individual quarter, cow or herd basis.

Generally, a composite udder sample with a count above 150,000 and 120,000 cells/ml for cows and heifers respectively means the animal is highly likely to be infected in at least one quarter. These are the currently accepted thresholds for infection used in the SAMM Plan.

The ICSCC information can be used in the selection of cows requiring lactational treatment, early drying off, dry cow treatment, temporary removal from the herd, culling, and monitoring the effectiveness of mastitis control programmes. It is a very reliable indicator of the infection status of a cow.

## b) Bacterial culture

For herds with a mastitis problem, it is essential to determine the types of bacteria causing the infections. It is not possible to identify these bacteria simply by looking at the milk, udders or SCC. Instead a small sample of milk is collected aseptically from the individual quarters and submitted to a microbiological laboratory for culturing. The milk samples are spread onto a sterile agar plate, incubated over 48 hours, and the bacterial colonies that grow are identified.

The culture results are important for fully understanding the specific problems affecting a herd, making recommendations for effective treatment, selecting management strategies, and making culling decisions on individual cows.

Bacterial culture is recommended whenever a herd problem exists, i.e. either more clinical cases than acceptable, or rising somatic cell counts. It is also useful in recurring cases for identifying further treatment strategies and identifying antibiotic resistance.

It is a good insurance policy to collect samples (taking the aseptic precautions outlined on the next page) from quarters with **clinical mastitis** before treatment and store them *frozen*. Submit them to your vet if a cow fails to respond to treatment, or there are a higher number of cases than you expect. Samples collected within 1-2 weeks after antibiotic treatment are highly unlikely to grow bacteria so collect samples before commencing treatment.

When investigating a herd with a **high BMSCC** problem, it is important to identify the type of bacteria causing the infections. This will help in deciding the control strategy since some bacteria are more likely to respond to antibiotic treatment than others are. It is important to collect samples from a representative number of cows and quarters – discuss strategies with your vet.

## Collecting milk samples

Farmers can collect milk samples for bacterial culture with excellent results, provided a few rules are followed closely.

*Very thorough hygiene* is needed to avoid getting bacteria from outside the teat into the milk sample, making it useless for identifying the cause of the infection. Spread of bacteria between cows can also occur, so it is important to disinfect hands after each cow.

## How to collect a milk sample

1. Label the sterile bottle (available from your vet) with the date, your name, the cow's number, the quarter sampled.
2. Disinfect the teat ends. This step is critical. If you are sampling more than one teat, disinfect the ones furthest away first then the near teats. This avoids accidentally brushing against the cleaned teats.

Vigorously rub the teat end for 10-15 seconds with cotton wool soaked in 70% alcohol and finally wipe any alcohol drops off the end of the teat. Alternatively, rub clean the teat end with an alcohol impregnated teat wipe, then spray with 70% alcohol. (A mixture of 7 parts methylated spirits and 3 parts purified water will substitute for the alcohol).



3. Allow the teat to dry.
4. Discard 3 squirts of milk from the quarter, to flush out any teat canal contaminants.
5. Strip 1-2 good squirts of milk (5-10ml) into a sterile bottle, holding it in a near horizontal position so that dirt from the udder does not fall into it. Keep the inside of the lid facing down for the same reason. Immediately secure the lid.

If you are collecting samples from multiple quarters, take the samples from the teats closest to you first, again to lessen the risk of contaminating the sample.



6. Clean your hands after each cow using the alcohol spray.
7. Refrigerate or freeze all samples immediately after milking to retain freshness.
8. Deliver the refrigerated samples to your vet clinic that day, or freeze until delivery is arranged.

## Antibiotic selection

The same milk sample can be tested for antibiotic sensitivity of the bacteria. This helps in the recommendation of a suitable antibiotic treatment.

The test involves growing bacteria from a sample of the cow's milk in the presence of different antibiotics.

The test gives an indication of which antibiotics are likely to be effective if used to treat the infected quarters.

Most infected cows respond fairly well if treatment is given early, for long enough, and if the bacteria is susceptible to the selected drugs. However, a single species of bacteria such as *Staph. aureus* has many strains or types that may vary in their susceptibility to a given antibiotic. If, for example, a bacteria is resistant to a drug such as penicillin in a laboratory test, selection of penicillin for treatment of the cow would be a waste of time. On the other hand, if a specific antibiotic works in the laboratory test it does not necessarily mean that that antibiotic will be effective in controlling the infection in the cow. This apparent contradiction is due to the many treatment difficulties in the live animal, such as getting the antibiotic through partially blocked milk ducts to the site of infection. To decide on the preferred antibiotics and their use, whether into the udder (intramammary) and/or systemic (injectable), you are best guided by your vet.

### Don't delay treatment

Note that although culture information is valuable, so is early treatment. Start treating a clinical case of mastitis whilst waiting for the results – the course of treatment can always be changed later if the first choice of treatment was not appropriate. Collect a milk sample before treatment and store them frozen in case bacterial culture is required later.

### Follow-up

If infected cows fail to respond to treatment, additional milk samples should be taken. However, because the antibiotic residues can affect the test, you should wait at least two weeks following the last treatment before taking the samples.

If the most suitable antibiotic is being used and proper management of the infection is being practised but there is still no response, then a general guideline is to dry the quarter off after the third time it has been treated. Consult with your vet.

## Drying off a quarter during lactation

### How to dry off a quarter during lactation

1. Clearly mark the quarter and cow.
2. Complete the course of lactating cow antibiotics (**do not** infuse with dry cow antibiotics).
3. Stop milking the quarter to be dried off – don't apply the cups.
4. Teat spray well. Do not milk out by hand, ignore that quarter.



# Treatment of mastitis

A new clinical mastitis case should be treated promptly, when first detected, with a full course of lactating cow antibiotics. Early detection and treatment increases the chances of a cure because the bacteria are in a rapidly multiplying state when they are most susceptible to antibiotics and there is less swelling and fewer clots to block access of the infused antibiotic.

Cows that have had clinical mastitis during lactation, or a pre-existing, chronic infection, should be treated with dry cow antibiotic treatment at drying off.

A number of options are available for treating mastitis.

## Lactating cow antibiotic treatments

The standard first choice of treatment for a new clinical infection in a lactating cow is a course of lactating cow antibiotics. Clinical infections in dry cows can also be treated in the same way. It is important to treat clinical mastitis early, and to use a full course of the antibiotics recommended by your vet.

Antibiotics used to treat clinical mastitis are either intramammary or injectable products. When treating cows with intramammary products it is important to use an aseptic technique. This involves cleaning the teat end with an alcohol wipe and alcohol spray, then infusing the tube of antibiotic into the infected quarter. Injectable antibiotics may be recommended in some situations, eg. multiple quarters infected. Consult with your vet.

All antibiotics are Prescription Animal Remedies and can only be obtained through your vet following a consultation. Be guided by your vet in choosing an antibiotic and read the information on the label before commencing treatment.

Milk and meat must be withheld from the dairy company supply from the commencement of treatment until the end of the recommended withholding periods stated on the drug label. The discarded milk cannot be fed to bobby calves but should be disposed off by other means. It is now mandatory that all treatment details be recorded.

## Intramammary antibiotic treatments

### How to administer intramammary antibiotic treatments

1. Milk and or strip out the quarter fully before infusing the antibiotic.
2. Completely disinfect the end of the teat(s) to be treated. Vigorously rub the teat end for 10-15 seconds with cotton wool soaked in 70% alcohol finally wiping any alcohol drop off the end of the teat. Alternatively, rub the teat end clean with an alcohol impregnated teat wipe then spray with 70% alcohol. (A mixture of 7 parts methylated spirits and 3 parts purified water will substitute for the alcohol).



3. Infuse the contents of the antibiotic syringe into the teat.



4. Teat spray treated quarters immediately after infusion.
5. Clearly mark the treated cow and treated quarter.
6. Segregate the treated cow.

Minimise the spread of bacteria from infected cows to other cows by running treated mastitis cows as a separate mob and milking them last.

7. Record all treatments.

Use the full course of antibiotics.

Observe withholding times for milk and meat.

Discard milk from all quarters of cows that receive treatment.

Do **not** use quarter milkers, as some antibiotic will be absorbed into the blood stream and passed out in the milk from the untreated quarters.

## Supportive treatments

Treatment for clinical mastitis may be supported by the following:

### Milking before treating

The infected quarter should be stripped out as much as possible before infusing the antibiotic. This helps to get rid of the infected milk, clear the milk ducts enabling the antibiotics to reach the site of infection, and reduces dilution of the antibiotic.

Lactating cows being treated for clinical mastitis should be milked out completely twice daily. More frequent milking may aid the cure rate because getting rid of the milk also gets rid of the bacteria and toxins in the milk. Dry cows being treated for clinical mastitis should be stripped out thoroughly by hand before infusing each tube.

### Injectable treatments

In severe cases of clinical mastitis, particularly where the cow is sick, additional injectable antibiotics may be given to supplement the intramammary treatments. Consult with your vet.

### Udder massage

It is well worthwhile spending time massaging the udder or infected quarters. This stimulates blood flow through the affected tissues, which encourages the healing process, as well as helping to remove all the infected milk before the intramammary treatment is given.

### Let-down hormone

The let-down hormone oxytocin can be used to assist with emptying of the udder in the more severe cases of mastitis.

Oxytocin is available as an injectable drug. It is a Prescription Animal Remedy and can only be obtained through your vet following a consultation.

## Dry cow antibiotic treatments

Dry cow antibiotics are slow release formulations that have been specially prepared for infusion into the udder immediately after the last milking of lactation.

Dry cow antibiotic treatment is an essential part of mastitis control and can be used to treat existing infections that have not cured during lactation.

Cure rates for dry cow antibiotic treatment at drying off are often better than for lactation treatment. Dry cow antibiotic formulations have prolonged antibacterial activity and may achieve better tissue penetration than lactating formulations. Dry cow formulations are designed to remain in the udder at concentrations high enough to kill mastitis bacteria for a long period of time. These periods can vary from 20-70 days, depending on the particular product and may be more likely to cure infections embedded deep in the udder tissue.

Cure rates with dry cow antibiotics, although better than for lactating cow antibiotic treatments, are still not 100% and vary according to the bacteria causing the infection (see table on page 40).

## Withholding times

Watch this, as there are severe penalties for careless management of antibiotic treatments.

Withholding times for meat and milk are shown on the label of all antibiotic treatments. For further information contact your vet. The penalties for antibiotic residues in the milk are very high. Make sure your systems are foolproof to keep antibiotic contaminated milk out of the bulk milk tank. Don't feed antibiotic contaminated milk to bobby calves. It is now mandatory (as part of your dairy company Product Safety Programme) to record all treatment details.

**Lactating cow antibiotics.** These are used for the treatment of clinical mastitis. Milk and meat withholding periods vary from product to product. Consult with your vet.

**Dry cow antibiotics.** These are infused only at the last milking of the season. The subsequent milk from the newly calved cows must be discarded for the first eight milkings because some antibiotic continues to be released into the milk.

If the cow calves within 6-8 weeks of dry cow treatment, check the drug label for detailed information on the milk withholding period for the specific product. Milk must not be sent for processing until it is tested negative for antibiotics. Alternatively, the milk should be kept out of the bulk milk tank for the length of the recommended 'dry period' plus an additional 8 milkings.

## Culling

Culling chronically infected cows is an important part of mastitis control. When repetitive treatments or other treatments have been tried but failed, culling becomes the more cost effective and humane option.

In many herds a small percentage of cows are responsible for a major portion of subclinical and clinical cases of mastitis. Culling reduces the bacterial risk to 'clean' cows, and may have a significant impact on BMSCC.

Although it is possible to reduce the mastitis level in a herd by culling, it is an expensive option. It is important that attention is also focused on the reasons for the mastitis problem and that steps are taken to prevent new infections, as mastitis problems are seldom solved by culling alone.

### Culling criteria

Culling should be part of a long term programme to reduce mastitis to a minimum.

The following should be considered:

#### **Production data**

Weigh up the costs and benefits. For a high producing cow, an alternative option may be to dry off the infected quarter and defer culling until production declines.

**Clinical mastitis history**

If the cow has had several bouts of clinical mastitis a cure is unlikely and she should probably be culled.

**Subclinical mastitis history**

If you are being penalised for a high BMSCC, culling a few high SCC cows or drying off some quarters may reduce the herd average below the penalty level – a short term ‘cure’ for a long term problem!

**Previous dry cow antibiotic treatment**

If the cow has already had dry cow antibiotic treatment because of a high SCC or clinical infection and still has a high SCC, say above 400,000 cells/ml, then the cow should probably be culled.

**Bacteriological check**

If the cow is known to have a *Staph. aureus* infection she is much less likely to respond to dry cow antibiotics than a cow with a known strep. infection.

**The new infection rate of the rest of the herd**

If mastitis spread is under control the high SCC cow is less of a risk.

## Curing an infection

**Expectations of a cure**

*Give the first treatment your best shot!* The cure rate following treatment during lactation for a first infection is around 75% (depending on the bacteria), for a recurring second infection it is 45% and from then on there's less and less hope (see tables below).

**Effectiveness of repeated lactational antibiotic treatment of recurring infections**

<i>Treatment No.</i>	<i>Treatment cure rates</i>
First time infection	75%
Second time infection	45%
Third time infection	12%

(Eden, 1992)

**Effectiveness of antibiotic treatment against mastitis (from 6000 treated infections)**

<i>Bacteria</i>	<i>% mastitis infections cured</i>		
	<i>Clinical</i>	<i>Subclinical</i>	<i>Drying off</i>
<i>Staph. aureus</i>	26	52	61
<i>Strep. agalactiae</i>	85	100	99
<i>Strep. dysgalactiae</i>	90	98	96
<i>Strep. uberis</i>	77	82	87

(Eden, 1992)

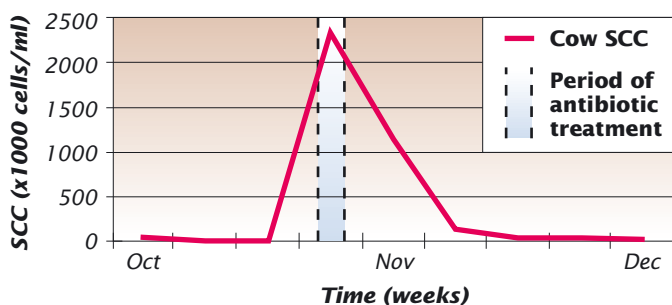
The sooner antibiotic treatment is started on a new infection, the better the chance of a cure. The cure rate of clinical mastitis varies due to differences in the product used, dose used, duration of treatment, the number of times clinical cases are re-treated and the bacteria present. Studies report cure rates from almost 100% for many streptococcal infections to less than 30% for long standing staphylococcal infections (see table above).

To achieve a good cure rate, new infections should be treated as thoroughly and as early as possible, especially in heifers where the chance of a cure is greatest.

## Assessing a successful cure

When a case of clinical mastitis is being treated, the clinical signs should start to subside within 48-72 hours of starting treatment. However the cow SCC will not reduce to low levels for at least 21-28 days after treatment and may remain elevated for some months (see graph below). Monitoring clinical signs is the best way to assess a successful cure, as conductivity and RMT results can take some time to return to normal.

### Changes in weekly SCC for a cow following successful antibiotic treatment and cure of clinical mastitis



## Lack of success

The reasons for the low and often disappointing cure rates that follow antibiotic treatment of mastitis fall into six main categories:

### 1. Drug penetration

The drug may not have reached the sites of infection in the udder because:

- the milk ducts are blocked due to clots and swelling, scar tissue, and abscess formation
- the bacteria may be walled off within tissue and somatic cells

### 2. Drug concentration

An inadequate concentration of antibiotic to kill bacteria may occur due to:

- poor distribution within the udder tissues
- too rapid transfer of the drug from the milk into the bloodstream following intramammary infusion
- too short a duration of treatment

### 3. Drug suitability

The bacteria may be resistant to the drug because:

- they are not in a rapidly multiplying state
- the bacteria may have acquired resistance to the drug being used

### 4. Re-infection

It is possible that the treatment did work, but the quarter has become re-infected, especially where teat ends are damaged.

### 5. Damaged teat end

Teat end damage caused by machine faults can continue to make teats susceptible to re-infection.

### 6. Chronically infected quarter

If a clinical quarter fails to respond (after a full course of treatment) consult with your vet. Options to discuss include repeating the same treatment, trying a different antibiotic, using an injectable antibiotic, culturing the pre-treatment sample or re-sampling the quarter, drying-off the quarter, drying-off the cow, or culling the cow.

## Cost benefits of treatment

### a) Clinical mastitis

Concern for the welfare of the animal dictates that clinical mastitis cases should be treated as soon as they are detected.

Apart from the animal welfare aspects, there are financial benefits associated with treating clinical mastitis during lactation. The benefit of treating a clinical case of mastitis during lactation has been estimated to be 2.5 times the cost of the treatment (McDougall & Beal, 2000).

The costs include the antibiotics and discarded milk, the indirect costs of retreating the same infection at a later date, and the labour costs associated with treatment, recording and follow-up.

The benefits include reduced production loss following treatment, reduced culling and replacement costs of chronically infected cows and a general reduced level of infection across the whole herd.

### b) Subclinical mastitis

Costs and benefits vary depending on the BMSCC, the stage of lactation, the age and production of the cow, the type of infection, the antibiotics used and the duration of antibiotic treatment. For example, younger cows with new *Strep. uberis* infections are more likely to cure, and be more economical to treat, than older cows with chronic *Staph. aureus* infections. Consult your vet.

# Prevention of mastitis

## 1. General preventative strategies

Mastitis is a complex disease. It results from an interaction of many factors, including the cow, her environment, her management (including milking), milking machine factors and the type of bacteria. To prevent mastitis, bacteria must be prevented from reaching the delicate secretory udder tissue.

Different bacteria have different ways of reaching the teat end and entering the udder, and generate different immune responses. **Cow-associated bacteria** generally contaminate the teats during milking whilst **environmental bacteria** contaminate the teats between milkings or during the dry period. Preventative measures vary in their effectiveness against each type of bacteria, so all the preventative measures must be applied for mastitis prevention to be effective.

Mastitis preventive strategies should aim to:

### a) Reduce bacteria at the teat end

If bacterial numbers at the teat end can be reduced, the chances of bacteria penetrating the teat canal are greatly reduced. Regular use of teat sanitisers after milking reduces the number of cow-associated bacteria around the teat opening.

The risk of teat damage should also be minimised since teat skin wounds, particularly at the teat orifice, provide a wonderful niche for some bacteria. A small amount of teat damage is normal during periods of wet weather, especially in early lactation, but widespread teat end damage is usually the sign of a poorly adjusted milking machine.

### b) Prevent bacteria from entering the teat

How bacteria enter the teat is not clearly understood. Particular risk times are during and immediately after milking, when the teat canal is open, and in the early dry period and around calving, when pressure in the udder may cause the teat to leak milk.

A faulty or incorrectly used milking machine can create conditions that result in increased propulsion of bacteria towards the teat end during milking.

Use of dry cow treatments can help prevent or deal with bacteria that enter the teat canal in the early dry period.

### c) Stop the spread of bacteria

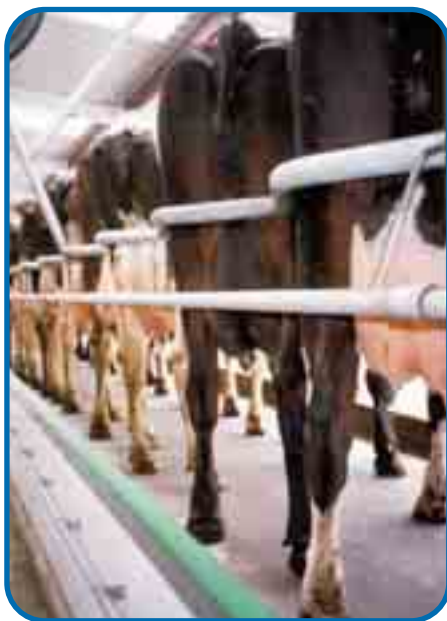
Bacteria usually reach the teat by physical contact with a contaminated surface such as the teat cup liners, milker's hands, soil, pasture and manure.

Cow-associated mastitis bacteria are passed from cow to cow at milking time, via the milking machine equipment. One infected cow can contaminate the teat cup liners which in turn can contaminate the next 5-6 cows milked with the same set of cups. Thorough use of teat sanitisers after milking will help to kill off the bacteria left on the teats. Cows with

clinical mastitis should be run as a separate mob and milked last.

To control a mastitis problem due to cow-associated bacteria, consider segregating the high SCC chronic cows (eg. multiple infected quarters or ICSCC above 250,000 cells/ml) and milking them last to avoid contaminating the uninfected cows.

Environmental mastitis results from contamination of the teats between milkings or when the cow is dry. Reducing this environmental challenge is more difficult. Research overseas suggests that pre-milking teat dipping may help reduce the level of environmental mastitis, particularly coliform mastitis – the evidence for *Strep. uberis* mastitis is less substantial.



**Milk infected cows last to avoid contaminating uninfected cows**

#### d) Remove sources of infection

Removing the sources of infection is more difficult.

For mastitis caused by **cow-associated bacteria**, the source is usually other infected cows and segregating, curing or culling are the main options. However, these cows are often difficult to cure and may still be producing their share of farm income. In time, these cows will leave the herd for other reasons but steps must be taken to minimise the spread of infection to the young uninfected animals.

For mastitis caused by **environmental bacteria**, the major source of the bacteria is not known but they have been isolated from faeces, the cow's belly, flanks, vagina, and nasal passages, and from pasture. Calving down on clean dry pastures and avoiding muddy races may help to reduce exposure. Heifers are particularly susceptible to environmental mastitis and are most at risk of infection during the last 3-4 weeks before calving.

### Human factors

Beware a complacent attitude, every herd has some infected cows. People's attitudes and actions can have an enormous impact on the control of mastitis.

Milkers need clear operating standards. These standards should outline your objectives as regards managing mastitis, highlight the need for good levels of monitoring and observation, and detail the routine procedures and situations requiring prompt actions.

Poor management can compromise the natural defences of the cow and increase the chances of mastitis. Effective management supports and enhances the cow's natural defence mechanisms.

## Set targets and review regularly

Good management relies on good information. Keep detailed records of clinical and subclinical cases and treatments administered. Keep herd test records together in a retrievable system. Once a month, review all the collated information and reassess your control activities.

Before mating starts, review the early season mastitis records. Consider the percentage of infected cows and clinical mastitis cases that occurred in each of the following groups:

1. Heifers
2. Cows – low SCC last season, no dry cow treatment received at end of last season
3. Cows – low SCC, received dry cow treatment (antibiotic or Teatseal®)
4. Cows – high SCC, received dry cow antibiotic treatment

The relative proportion of your herd in each of these groups highlights any 'problem' group of cows and will be helpful in identifying an appropriate control strategy for your herd.

Defined targets are invaluable for measuring progress in the control of mastitis. These include the BMSCC; the number of heifers in the low SCC range and the number of clinical mastitis cases observed in heifers and older cows. Work with your vet or advisor to establish standards to suit you and meet your objectives.

## Preventing infections around calving

Our understanding of the part that management, environmental and biological factors play in preventing mastitis around calving is limited, as there is very little research data.

However, it is generally believed that:

- calving should take place on 'clean' pasture, avoiding muddy paddocks.
- it is important to maintain normal levels of trace elements such as selenium, copper and zinc. These are important for mammary immunity.

Trial work has also identified that the use of dry cow antibiotics or Teatseal® at drying off in 'uninfected' cows can prevent new *Strep. uberis* infections during the dry period and around calving (see page 50). An important outcome of this research was the finding that teat canal plugs should remain in place until calving to prevent new infections. If the teats are leaking milk, machine milk before calving to relieve the pressure. (Make sure that milk is withheld from the bulk milk tank until 4 days after the cow calves.)

It is also important to identify and treat early any cases of mastitis. Check cows twice daily in the colostrum mob for clinical signs of mastitis – clots, watery or discoloured secretion.

## 2. Teat sanitation

The single most effective way of controlling the transfer of bacteria from cow to cow is by teat sanitation.



### Teat sanitation for New Zealand conditions

In New Zealand, teat sanitation usually refers to teat spraying carried out immediately after cluster removal at the end of milking, ie. post-milking teat spraying.

In New Zealand, teat spraying has been found to be more convenient than teat dipping, and spraying can also be automated. Both dipping and spraying have been shown to prevent new infections by a similar degree as long as the entire circumference of the teat, for at least half of its the length is coated with sanitiser (Pankey and Watts, 1983).

As well as having an antibacterial function, most teat sanitisers contain an emollient to improve teat skin condition.

Some teat sanitiser labels refer to a high risk or low risk period, and give different dilution rates for each. The stronger mixes are used when mastitis risk is higher in early lactation or when there is teat damage.

Use water of drinking quality to dilute the product.

Use teat sanitisers with an emollient. Mix according to the label.

## How to teatspray

For teat sanitation to be an effective control measure, follow these recommendations:

1. Teatspray all teats of all cows immediately after every milking throughout the complete lactation.

Teatsprays should be applied as soon as the cups are removed. For maximum effectiveness, teatsprays should be applied from directly underneath the tips of the teats, not sprayed from the side.

2. Cover the whole teat of every cow at every milking to maximise effectiveness.

Teat spray should cover the whole area of the teat that is exposed to the liner, ie. at least half the length of the teat. About 20 ml of the diluted teat spray should be used/cow/milking, ie. every 100 cows, requires 4 litres of diluted teat spray per day.

3. A new batch should be mixed at regular intervals, ideally at least every 2-3 days.
4. Use an approved product that has 'Passed Protocol A 1997' on the label. Products carrying this statement have been independently tested and proven to meet minimum teat sanitation efficacy standards under laboratory conditions.

Extra emollient may be added in early spring when the teats are at their most tender, but do not exceed 15% in the final mixture. In iodine based sanitisers, high levels (above 15%) can interfere with the killing power of the disinfectant.

In addition to their use during lactation, teat sanitisers can be used over the 7-10 days prior to calving and whenever cows are yarded during the dry period, to minimise bacterial contamination of the teats.



***Cover the whole teat with teatspray after every milking***

## How teat sanitation works

The two primary objectives of teat sanitation are to reduce the numbers of bacteria on the teat skin and to enhance teat skin condition. Teat sanitation works by:

- Killing and preventing growth of bacteria on the teat skin and inside the teat orifice between milkings.

- Healing lesions and minor scratches. Bacteria thrive better on chapped, roughened skin than on smooth, supple skin.
- Improving the teat condition to enable it to better withstand the stresses of milking. Cows are less likely to fidget and kick off the cups if their teats are in good condition. This reduces liner slippage, vacuum fluctuations and milker irritation.

## Effectiveness of teat sanitation

Most teat sanitisers lose effectiveness within hours of application. Hence post-milking teat spraying is mainly effective against cow-associated bacteria (which spread at milking) rather than against environmental bacteria (which contaminate teats between milkings).

Teat sanitation after milking has been found to reduce new infections (clinical and subclinical) due to cow-associated bacteria such as *Staph. aureus* by 50% (Lam, 1996).

Teatspraying the whole teat surface of all teats of all cows should also control minor bacteria like *C. bovis* and Coagulase negative staphylococci. Infection rates with these minor bacteria can become very high by the end of the season in herds which do not practise effective teatspraying. Minor bacteria increase the BMSCC and increase the risk of new infections with major bacteria.

## 3. Drying off management

### Preventing high BMSCC before drying off

- **Dry off high SCC cows before** starting to dry off the main herd. Their SCC will increase dramatically as milk yields reduce and/or if milked once-a-day. Clinical mastitis may also occur in these cows. Dry off by ceasing milking. Cull or treat with dry cow antibiotics if being retained until next season.
- **Dry off low yielding cows (less than 5 litres/day) before** starting to dry off the main herd. These cows have a high SCC because they are 'drying themselves off'. Their SCC will continue to rise as they produce less milk and more dry cow secretion.
- **Clearly mark the udders of cows that have been dried off early** to prevent unintentionally milking them into the bulk milk tank if they happen to get back into the milking herd.
- **Don't practise 'skip-a-day' milkings.** This increases cow SCC and increases the risk of clinical mastitis.

### Drying off the herd

Udder infections during the dry period and in the following lactation can be minimised by events at drying-off. The aim is to shut down milk secretion and allow the teat canal to seal as rapidly as possible. Typically, 50% of teat canals become sealed with a keratin plug within 10 days of drying off. Others form a plug progressively over a period of weeks. Until this plug is formed, there is risk of clinical mastitis due to environmental bacteria such as *Strep. uberis*.

## How to dry off

1. Decide the date of final milking.
2. Reduce daily milk yields to between 5-10 l/cow.  
If cows are producing below 10 litres, no additional steps are required. If cows are producing above 10 litres, reduce feed intake to reduce milk yields. Switching to once-a-day milking may also help reduce milk yields whilst conserving cow condition. Note: Once-a-day milking is not recommended for high SCC cows, as their SCC will increase dramatically and clinical mastitis may develop.
3. Reduce feed intakes to maintenance levels for the last 2-3 days before drying off. Keep water available.
4. Administer dry cow treatments after the final milking.  
Do not milk again after treating with dry cow treatments.
5. Continue feeding at maintenance levels for 7 days after drying off.  
When most of the cows have stopped bagging up, start increasing feed levels to put condition on the cows.
6. Monitor for signs of clinical mastitis for the first 3 weeks of the dry period.

One week after drying off inspect each udder for heat, pain or swelling, and continue at weekly intervals for at least 3 weeks. Do not remove milk or secretion unless quarter has clinical mastitis. New clinical mastitis cases should be treated with a course of lactating antibiotic treatment.



## Objectives of dry cow treatments (DCT)

### 1. Curing pre-existing infections

Dry cow antibiotics are a slow release formulation of antibiotic that has been specially prepared for administration into the udder immediately after the last milking of lactation.

Dry cow antibiotic treatment is an essential part of mastitis control and is used to:

- treat existing infections that have not cured during lactation
- promote faster keratin plug formation
- reduce the number of new infections that may occur during the dry period in uninfected cows
- reduce clinical and subclinical mastitis at and around calving

### 2. Preventing new infections

Animals that have a low SCC and no previous record of infection may be infused at drying off with either (a) dry cow antibiotic or (b) non-antibiotic Teatseal®. These treatments help to prevent new infections from developing over the dry period and around calving.

#### a) Dry cow antibiotic treatments

Dry cow antibiotics protect the udder from new infections by killing invading bacteria before teat plug formation has taken place. The activity of the antibiotic has a finite life and its protective effect may reduce near calving, particularly if the dry period is longer than 8-10 weeks. At this time the cow may rely more on her own natural teat canal defences to prevent bacteria entering the udder.

#### b) Teatseal®

Teatseal® is an inert substance that is infused into the teat of **'uninfected'** cows at drying off. Following infusion, the material fills the teat canal and lower part of the quarter and acts as a physical barrier to any invading bacteria. Because the product is so dense and inert, it is not absorbed and it remains in place until the cow calves. The sealant material is easily removed at the first milking after calving and is harmless to suckling calves.

Since Teatseal® contains no antibiotics, its use reduces the risk of inhibitory substance penalties at the start of the next lactation. However, because it contains no antibiotics, great care must be taken at the time of administration.

This product should only be used for uninfected animals. An 'uninfected' animal is one that, since the previous drying off, has had:

- An individual cow SCC below 150,000 cells/ml (for cows) and 120,000 cells/ml (for heifers), and
- No record of clinical mastitis since the previous drying off

Provided that more than 60% of the cows in a herd can be classified 'uninfected', then Teatseal can be used in the 'uninfected' animals.

#### Field study results

Experiments conducted under New Zealand conditions by the Dairying Research Corporation have demonstrated the benefits of using either a long acting dry cow antibiotic or Teatseal® to prevent new mastitis

infections during the dry period and around calving in ‘uninfected’ cows. The results of three separate field trials were similar. Long acting dry cow antibiotic treatment, and treatment with Teatseal®, both achieved the following compared to untreated quarters:

1. Reduced clinical mastitis by *Strep. uberis* in the dry period by 80-100%.
2. Reduced *Strep. uberis* infections at calving by 80-95%.
3. Reduced clinical mastitis in the first 4 months of lactation by at least 50%.

## Dry cow treatment strategies

A number of strategies are available for use as dry cow treatments, depending on your current mastitis situation, your goals for mastitis control and financial consequences of each strategy. To assist your decision, collect together the recent herd test records and the clinical mastitis records from the last dry period and current lactation and discuss them with your vet.

Farm management goals will also have a bearing on your dry cow treatment decisions. For example, consider whole herd treatment (ie. the treatment of all quarters of all cows) for herds that you are selling or sending directly to the run off after drying off or to reduce time and labour associated with clinical mastitis at calving.

The strategies are:

### 1. Whole herd treatment

This means treating all quarters of all cows at drying off. The purposes are twofold – to treat pre-existing infections and to prevent new infections. All cows with existing infections are treated with a dry cow antibiotic and, depending on the herd mastitis situation, the uninfected cows are treated either with a dry cow antibiotic or a non-antibiotic alternative such as Teatseal®.

**Antibiotic dry cow treatments are Prescription Animal Remedies so consult with your vet to decide the dry cow treatment options that best meet your herds needs and your farm management goals.**

### Option A – Treat all quarters of all cows with dry cow antibiotics

**Use this option if:**

- The herd has a relatively high level of clinical mastitis in early or late season and/or the early dry period.
- The herd has a relatively high BMSCC.
- Your aim is to significantly reduce the herd BMSCC and/or level of clinical mastitis in the herd.
- Your management goals require, or your management systems allow, less emphasis on checking for mastitis in the dry period or after calving.

## Option B – Treat all infected cows with dry cow antibiotics and all uninfected cows with Teatseal®

This option is similar to option A except that non-antibiotic Teatseal® can be used in uninfected cows as an alternative to dry cow antibiotic treatment. Use only if the mastitis situation and BMSCC is well controlled. Provided that more than 60% of the cows in a herd are 'uninfected' (see below) then Teatseal® can be used in 'uninfected' animals.

### Use dry cow antibiotics for:

- Cows that have had an individual SCC above 150,000 cells/ml and heifers above 120,000 cells/ml at any herd test in the season to date.
- Any animals that had clinical mastitis since last dry off.
- Any animals that have a 'suspect' mastitis history, ie. incomplete or unknown mastitis records.

### Use Teatseal® for:

- 'Uninfected' cows. These are ones that in the season to date have had an individual SCC below 150,000 cells/ml (for cows) and below 120,000 cells/ml (for heifers) and have had no clinical mastitis since the previous drying off period.

## 2. Selective treatment

This means treating the known infected cows with dry cow antibiotics and leaving the 'uninfected' cows untreated. Consider this option only if the mastitis situation is under good control and if you are prepared to accept the risks of not providing protection for your 'uninfected' cows.

### Use dry cow antibiotics for:

- Cows that have an individual SCC above 150,000 cells/ml and heifers above 120,000 cells/ml at any herd test in the season to date.
- Any animals that had clinical mastitis since last dry off.
- Any animals that have a 'suspect' mastitis history, ie. incomplete or unknown mastitis records.

## Dry cow treatments

It is critical that antibiotic dry cow treatments or Teatseal® are administered carefully as bacteria can be easily introduced into the teat if the teat end is not disinfected properly. These introduced bacteria can cause severe clinical mastitis.

## How to administer dry cow treatments

1. Allow plenty of time to treat animals. Treat cows in manageable mobs. Ensure that responsible operators are trained adequately in the treatment procedure and supervised well.
2. Use dry cow antibiotics or Teatseal® only at the cow's last milking for the current lactation.
3. Treat every quarter of each selected cow with the same treatment.
4. Vigorously rub the teat end for 10-15 seconds with cotton wool soaked in 70% alcohol finally wiping any alcohol drop off the end of the teat. Alternatively, rub the teat end clean with an alcohol impregnated teat wipe.
5. Spray the teat end with an alcohol based aerosol spray and allow it to dry. Alternately, use a methylated spirits based spray (made up by mixing 7 parts methylated spirits and 3 parts purified water).
6. Insert nozzle of the treatment tube no more than 3mm into the teat canal.  
Only partially inserting the nozzle into the teat canal in this way reduces teat end damage and has been shown in some trials to reduce the number of new infections at calving.
7. Spray teats with teat sanitiser after infusion.
8. Record cow number, date and product details of all dry cow treatments. Mark the udders of all cows given DCT earlier than the main mob.
9. Put cows in dry clean paddocks after drying off, to reduce teat exposure to environmental mastitis bacteria.
10. Strictly observe withholding times.



## Following dry cow treatment

Cows are susceptible to new infections, particularly in the first week of the dry period before the teat canal has sealed.

- Do not milk again after dry cow treatments.
- Continue feeding at maintenance levels for 7 days after drying off.
- Observe all cows every day for the first week after drying off while the cows are in the paddock. Check for particularly swollen udders or cows showing signs of illness. Bring any suspect cows into the dairy and check the udder manually.
- Inspect all quarters of all cows weekly for at least 3 weeks. Feel for hot/swollen quarters and only remove milk or secretion if the quarter is suspected of having clinical mastitis.

### If you discover a case of clinical mastitis:

- Separate the infected cow from the main herd.
- Strip quarter out completely and administer lactating cow antibiotics using a full course of treatment (dry cow antibiotics are NOT suitable at this time).
- Record treatment details.
- Spray teats after each treatment or examination with normal teat sanitiser.

## 4. Minimising teat damage

### Major cause of mastitis

Teat damage is a major reason for cows getting mastitis. Damaged tissue provides sites where bacteria can multiply. It is also an important indicator of faulty machines and/or milking techniques.

### Natural defences

The udder of a healthy cow has very good defence mechanisms to protect itself against infection. The teat sphincter or ring of muscles around the teat opening that shuts it tight between milkings is particularly important. Antibacterial substances that naturally occur in the teat canal and other parts of the udder are also important. The last line of defence is the somatic cells from the blood supply that enter the udder and into the milk to fight an infection.

Mastitis control measures should aim to keep the teat skin and teat end in good condition, and to repair any damage as quickly as possible before infection takes place.



***A healthy teat is one of the best defences against mastitis***

## Causes of teat damage

Teat damage can be divided into (a) Teat sores and (b) Teat end damage.

### a) Teat sores

Teat sores and cracks, provide sites where large numbers of bacteria can multiply. The greater the numbers of bacteria on the teat, the greater the risk of mastitis infections occurring.

When teat skin condition is poor, effective teat sanitation is difficult to achieve and the risk of new intramammary infections increases.

Teat skin health is affected by exposure to mud and water, and milking machine factors. Water is harmful to teat skin because it removes protective natural oils, increasing the likelihood of cracks developing on teats.

Extensive teat damage may also be due to not enough emollient in the teat sanitiser to cope with adverse weather conditions.

To maintain teat skin health, minimise exposure of teats to mud and water, use sufficient emollient in teat sanitisers, and maintain milking machine settings at the recommended levels.

### b) Teat end damage

An injury to the teat end dramatically increases the likelihood of mastitis. Bacteria can gain entry more easily through a damaged teat end. Injuries can be caused by the cow stamping on or tearing her own teats when she stands up, or by faults in the milking machine.

Milking machine factors that result in teat end damage can also upset the natural defences operating within the teat canal or duct. These factors include high vacuum levels, slippage of the teat cups, failure of the pulsation rest phase, liners that are too short for the teats, prolonged milking time and poor vacuum regulator performance.

## Signs of teat end damage

Checking the teats at milking time, particularly as the cups come off, will alert you to any possible problems. Some skill is needed as the same visible end result can have several prime causes. Look for:

- bluing of teat end
- pulled out teat ends
- teat orifice damage
- swelling of teat end
- pin-point bleeding
- wedge-shaped teat end
- blackspot
- horizontal rings

Teat end damage problems are often worse for cows that experience prolonged milking, ie. those that are slow milking, high yielding or are overmilked.

### Bluing

Bluing, as the name suggests, is a bluish or purple discoloration of the teat caused by congestion of blood in the teat tissues. This may be caused by the absence of pulsation, by defective pulsation, excessive vacuum or incompatible liner/shell combinations.

Bluing is usually accompanied by general teat swelling and a horizontal ring formed at the base of the teat. Congestion of the teat causes pain, and this is very likely to adversely affect milk let-down and result in poor milking out.

## **Pulled out teat ends**

'Pulled out', everted or eroded teat ends may indicate persistent high vacuum, faulty pulsation and/or persistent overmilking. A pulled out teat end can look like a wart-like growth on the end of the teat as part of the teat canal becomes exposed to the outside environment.

## **Pin-point bleeding**

Small hemorrhages are said to be the result of poor machine function and suboptimal pulsation, leading to inadequate teat massage during milking. These can eventually lead to teat end cracks and sores.

## **Blackspot**

Blackspot is a sore on the end of the teat, identifiable by its persistent black scab. It results from teat damage due to a faulty milking machine, where milking causes the teat orifice to prolapse and become ulcerated. Blackspot commonly leads to mastitis in the affected quarter.



***Practise good milking procedures and service your milking machine regularly to avoid teat damage***

# Milking management and the milking machine

## 1. Milking Management

### Milking routines

Most farmers do have a good milking routine but it is wise to check this each season, especially if there are new milkers in the farm dairy or a mastitis flare-up occurs.

#### Time the routine

The less time the cups are on the cows the better. Ten rows/hour in a herringbone is possible and eight rows/hour is an easy target. Is drenching too slow so the cups are on too long? Repair any problems, which may be causing inefficiencies, such as a broken backing gate motor, and keep people and objects clear of the bail entrance.

If there are two people milking, share the work out evenly. Work together quickly to change clusters, then split up the teat spraying, drenching and bailing up tasks.

Look for any fault causing back-jetting of milk (cup slip, dragging the clusters off too quickly before the vacuum falls). Poor alignment of the cluster with the cow leads to slow uneven milking and cup slip.

#### Let-down reflex

Only a small amount of milk is stored in the teat and the cistern above the teat; the rest is retained in the alveoli close to where it is produced by the secretory cells. Stimulation of the teats prior to milking activates a chain of events that is called the milk 'let-down' reflex. Gentle handling of the teats sends a nerve impulse to the cow's brain, which triggers the pituitary gland to secrete oxytocin, which in turn, via the blood stream, activates the small muscle-like tissue surrounding the cells of the alveoli to contract. The contraction causes milk ejection into the duct system of the udder.

The action of oxytocin is essential for complete let-down and emptying of the udder during milking. Its let-down action lasts 5-8 minutes and is strongest for the first 1-2 minutes of milking. It is important to get the clusters attached quickly and make full use of the increased udder pressure that occurs at let-down.

#### Make it pleasant!

Aim to make the milking process a pleasant experience for both the cow and the operator! Full co-operation from the cow is absolutely necessary. It is important not to upset the cow prior to or during milking or the 'hold-up' hormone, adrenalin, is released and counteracts the oxytocin activity.

It may take 15-20 minutes for the effects of adrenalin to subside. For these reasons timing and gentleness are important in harvesting the milk.

Poor stimulation, too long a lag time before attaching the clusters, slow milking, pain or upsetting the cow can rob you of full production. Incomplete milking may also increase the duration of existing mastitis cases.

Oxytocin can be administered to help cows achieve let-down (eg. in freshly calved heifers) and to aid more complete removal of milk in inflamed udders. Oxytocin is a Prescription Animal Remedy for use only following a veterinary consultation.

### Voltage protection

Shocks or stray voltage causes distress to cows, makes cows reluctant to enter the bail area, inhibits milk let-down and leads to overmilking. Clusters get kicked off or liners slip. All are liable to increase the level of mastitis.

Farm dairies should be built so that there is no risk of cows getting electrical shocks. Protection against voltage problems is easy. Ask your machine tester or specialist for a voltage test.

### Wash dirty teats only

To speed up and improve the milking routine, advisors recommend that you wash only the dirty teats. Washing with udder soap can lead to teat cracking and may even spread harmful bacteria. So use fresh, clean running water and rub thoroughly.

If you do have to wash teats, it is important to dry them, as milking wet teats increases the risk of mastitis and raises milk quality issues. Use individual disposable towels to dry wet teats.

If teats are dirty, check the races to ensure they are drained adequately and not contributing to dirty teats.

### Cow identification

Keeping treated cows in a separate mob reduces the risk of errors and ensures that milk from treated quarters is kept out of the bulk milk tank during the required withholding time. Identify on the cow itself which ones are infected or being treated, eg. udder marking or leg straps, in case the problem cow finds its way back into the main herd.

Any cows that are prone to repeat clinical infection should be more permanently identified so they can be checked more often.



***Clearly mark the cow to indicate which quarter is being treated***

## Product Safety Programmes

Product Safety Programmes are now in place for the milking cow, and cover disease, treatment, and recording and management actions.

The law requires that details of animals undergoing treatment for disease be recorded and available for inspection on the farm. Details must include the cow number, date the animal was identified, treatment given, date milk was withheld, the date milk was returned to the bulk milk tank and name of vet if consulted.

Where an animal's mammary gland is inflamed or injured, the affected quarter(s) are required to be identified to enable milk from them to be withheld until healing and/or resolution of clinical signs occurs.

## Run infected cows separately and milk them last

Once a cow with an infection has been milked, the bacteria are liable to be distributed throughout the milking machine. It is then possible for mechanical or operator faults to drive bacteria-laden milk towards the teat orifice of other cows. If that happens, a bout of mastitis may follow. To avoid this problem, run infected cows as a separate mob and milk them last.

Tracer studies at Dairying Research Corporation have demonstrated that teat cups spread bacteria among cows. A teat cup that has milked a subclinically infected quarter will then deposit bacteria from this infection on the teat skin of up to the next 5 cows milked with that cluster.

Outbreaks of mastitis due to cow-associated bacteria, such as *Staph. aureus* and *Strep. agalactiae*, occur in this way. Remember to rinse and then sanitise the cluster after milking each mastitis cow.

This is yet another reason why teat sanitising is important - it kills bacteria deposited on the teat by the milking machine.

## Practise good hygiene

Bacteria can be spread to other quarters and cows by splashes of milk that occur during stripping, by milkers' hands and by teatcup liners. As it is extremely difficult to disinfect the surface of hands it is advisable to wear gloves.

The routine use of gloves at all times while milking is a good practice, but especially when searching for or dealing with clinical cases of mastitis. It is also best to avoid getting milk on hands.

To disinfect gloves contaminated with infected milk during milking, firstly rinse them with running water and then dip them in a disinfecting solution such as 1% Iodophor.

## Segregating high SCC cows

Farmers who are being penalised or at risk of being penalised for producing high SCC milk may also find it worthwhile to segregate the worst subclinical cows (ie. high SCC) and milk them separately at the end of milking.

This helps prevent spreading mastitis to the low SCC cows and ensures these cows can receive special attention.

### Putting on clusters

Don't allow unnecessary air to enter cups when attaching clusters. The air admitted when clusters are attached or removed reduces the milk carrying capacity of the milkline.

### Avoid over milking

Over milking or slow milking accounts for many cases of sore teats especially in heifers.

### Machine stripping

It is important for the control of clinical mastitis to make sure that cows are milked out cleanly. If the cows are not milking cleanly, first look at the choice of liner, then seek advice from a milking machinery expert if the problem persists.

Machine stripping (the pulling down of the clusters a few seconds before they are removed) should be avoided. For the odd cow that needs the cluster pulled down or weighted be careful to avoid letting in air – which is the equivalent of liner slip and causes backjetting.

### Removing clusters

To stop any risk of back jetting, clusters should be removed slowly by shutting off the vacuum tap and allowing the vacuum to fall. Clusters with automatic shut-off devices are better than those without, as these prevent over-milking and prevent the vacuum from falling in the rest of the machine if a cluster is kicked off during milking.

### Feeding mastitis milk to calves

Mastitis, antibiotic contaminated milk can be fed to replacement calves (but not to bobby calves), or discarded. On the very limited evidence available, it is unlikely that calves that suckle on mastitis milk will have mastitis at calving two years later.

Remember that colostrum with antibiotic residues does not store very well.

### Putting calves on cows before and/or after milking

The practice of feeding calves by turning a number of milkers out into the calf pen before or after milking should be discouraged as the calves' mouths may transmit bacteria among teats and cows.

## 2. The Milking Machine

Many different aspects of the milking machine are implicated in the spread of mastitis, especially those affecting the milking time, level of teat damage and liner slip.

### Effect on mastitis

Milking machine factors that have a direct effect on teat end damage and mastitis are:

- Vacuum level
- Vacuum stability
- Pulsators
- Liners

Factors that have an indirect effect on mastitis include:

- plumbing
- milkline height
- milkline size/slope
- milkline inlets
- cluster air admission
- reserve vacuum pump capacity
- long milk tubes
- cluster alignment
- regulator function
- claws

## 1. Vacuum level

Field observations show a high level of infection may occur if the vacuum level is too high for the milking machine installation. Improvements occur if the vacuum level is reduced. Aim to have the vacuum in the claw between 36 and 42 kPa during peak milk flow.



### Guidelines for vacuum levels of machines with different milkline heights

<b>Rotaries</b>	<b>kPa</b>	<b>Herringbones</b> <i>(measured from where cow stands to milkline)</i>	<b>kPa</b>
Lowline	42	1.4m	44
Udderline	44	1.6m	46
		1.8m	48

(Eden, 1992)

Teat damage due to high vacuum is most likely to occur when the cups are left on after milk flow has stopped, so avoid over-milking. Since teat injury is a function of time as well as vacuum level, teat damage is likely to occur in cows that are high producers or slow milkers. Reduce the vacuum to prevent new damage and cure existing damage with a good teat sanitiser, and the problems should rapidly disappear.

Damage to the teat is also more likely to occur just after calving when teats are soft and tender, and unused to milking. Use a good post-milking teat sanitiser containing emollient to improve teat skin condition.

## 2. Vacuum stability

Factors affecting vacuum stability in the claw during milking include milkline height and slope, pulsation action, low vacuum reserve, faulty regulators, blocked claw air admission holes, and restrictions between the claw and milkline.

Modern regulators, properly installed are very good at maintaining a stable milking plant vacuum. Maintenance of the vacuum regulator and regular checking of its performance are both essential for proper operation. Vacuum instability at the teat end is more likely to be a result of other factors within the machine.

### **Milkline height**

During milking, plugs of milk are pushed up the long milk tube by the air entering the air admission hole in the claw. During peak milk flow these plugs may nearly fill the long milk tube, and cause the vacuum in the claw to be up to 10 kPa lower than the vacuum in the milk line. The vacuum drop increases as the milkline height increases.

As milking nears completion and milk flow through the long milk tube decreases, the vacuum at the teat end will gradually increase until it is nearly the same as the vacuum level in the milkline.

Lowering the milkline reduces the vacuum fluctuations in the claw, shortens milking time, and the exposure time to infection.

### **Cyclic fluctuations**

The vacuum level in the claw during milking also varies in a regular, routine fashion over a range of up to 10 kPa with the pulsator operation, as the liner opens and closes and as milk is 'pumped' out of the liners. This is part of the normal operation of a milking system and is referred to as cyclic vacuum fluctuation.

### **Irregular fluctuations**

Irregular vacuum fluctuations are the result of non-routine happenings within the milking system, such as teat cup slips, and inrushes of air during cluster changing.

In a well set up milking machine with a relatively low milkline, adequate effective reserve air, suitable non-slip liners, and operated without excessive amounts of air let in during cluster changing, irregular vacuum fluctuations will be negligible.

Vacuum level changes in the claw are greatest if there is a high milkline and/or restrictions to the free passage of the air. If the fluctuating vacuum makes the cups fall off or slip, the mastitis infection rate will rise. If the liners do not slip, a change in the vacuum level by having a low reserve vacuum pump capacity or clumsy cluster changing should have very little effect on the level of mastitis. However, it will slow down the milking rate and the mastitis level may then rise simply because the clusters are on the cow longer.

In a milking machine where irregular vacuum fluctuations are superimposed on the normal cyclic vacuum fluctuations, researchers have found a higher number of new infections. It is likely that this effect is an indirect one and the main mechanism for mastitis transfer, other than as a result of teat damage, is through teat cup slips.

There is a danger in over-emphasising the effects of unnecessary vacuum fluctuations. However, getting rid of them – or better still, designing equipment to overcome their effects – is considered an important part of a mastitis control program.

A number of experiments have compared the effect of unstable versus stable vacuum on new cases of mastitis. More than double the number

of mastitis cases were found in those cows milked using unstable vacuum compared with those milked using stable vacuum. Researchers have therefore urged manufacturers to try to minimise the effects of vacuum fluctuations with improved equipment design.

Get your machine checked and serviced regularly, and change clusters carefully so that there are no rapid inrushes of air especially as the cups are taken off.

### Preventing back-jetting

Research has shown that if air is let into one liner on a claw, it can cause droplets of milk that may contain bacteria to be pushed up into the other three liners with sufficient force to reach the ends of the teats in those liners. Mastitis may be transferred from quarter to quarter in this way.

Prevent back-jetting by minimising liner slips and removing clusters carefully, by shutting off the vacuum tap, allowing the vacuum to fall and the clusters to drop away from the cow.

## 3. Pulsators

Pulsators are simple devices that open and shut a valve to allow air in behind the liner to alternately open and close it. The liner is open during the milking phase, and closed during the rest phase. Pulsation is required to prevent a continuous vacuum being applied to the teat. Milking with continuous vacuum increases the pain and discomfort of milking, reduces milking speed and production and increases the risks of teat damage and mastitis.

Pulsators that are faulty, dirty or incorrectly adjusted will cause teat damage and increase the chances of mastitis.

### Pulsator rate and ratio

The pulsation ratio refers to the time that the liner is open in relation to the time it is closed. A ratio of 2 to 1 means that the liner is open for twice as long as it is closed – in percentage terms the ratio is 66%.

The current recommendation is for correctly adjusted pulsators to operate within the range of around 50 to 60 pulsations per minute with a ratio of 50 to 70%.

The important factor in this is the rest phase, which should be at least 0.15 seconds of every cycle. If the rest phase is too short, fluids will collect in the tissues at the end of the teat and cause swelling and damage that may lead to teat sores. Good indicators of this problem are the appearance of small blood blisters at or near the teat ends of the teats or a hardening of the teat end, observed when the cups are removed.

The frequency of teat sores and new infections increases when the pulsation chamber vacuum fails to reach zero during the rest phase. This can happen for a number of reasons including a rest phase that is too short or an open phase that is too long (greater than 75%), or liners that are too short for the teats or the teatcups.

Pulsation may fail if there are leaks in the pulsation system so it is very important to replace split or perished short pulse tubes.

With some electronic pulsation systems, farmers are able to easily adjust pulsation rates and ratios. Provided they are kept within the general range shown above, ie. the 0.15 second rest phase minimum is met,

there is unlikely to be any effect on mastitis. Wider ratios mean cows milk faster so clusters can be removed earlier.

### Optimum ratio

The aim is to milk cows quickly, cleanly and thoroughly. The 'safe' range is a rate of 50 – 60 pulsation cycles/minute and a ratio of 60-65%.

## 4. Liners

Well-designed liners in good condition, and matched to the herd, are essential for good milking. Good liners reduce stress or injury to the teat, which in turn reduces the risk of mastitis.

### Liner squeeze effect

As it opens or closes during the pulsation cycle, the liner allows a differential pressure to be applied to the teat end. During the closed or rest phase the liner collapses due to a vacuum inside the liner and atmospheric air pressure outside the liner. Fluids in the teat tissue are squeezed back up the teat and allow increased circulation of blood. The squeezing action depends on the maintenance of good liner condition and sufficient tension.

Contrary to popular belief, closing of the liner does not completely cut off the vacuum to the teat end. The benefit of the squeeze is to prevent teat fluids from building up in the end of the teat and blocking off the milk flow.

### Effect of liner length

When the cluster is applied to the cow, the length of the teat increases typically by up to 50% within the teat cup assembly. Very long teats or liners with a short effective length can result in the teat extending too far into the liner, below the level at which the liner closes. The result is teat injury due to failure of the rest phase (see table below).

Most liners on the New Zealand market have an adequate effective length.

#### Effect of liner length

<i>Length</i>	<i>Failure of rest phase</i>	<i>Teat damage</i>	<i>Infection</i>
148mm	14%	17	3
130mm	90%	42	26

(Mein, 1983)

### Seal

Failure to obtain a good seal around the top of the teat results in an increased occurrence of liner squawking or slip.

### Mouthpiece opening

Another consideration in liner selection is the diameter of the mouthpiece opening. Mouthpieces with narrow diameters may slow down milking by partially restricting the opening between the udder cistern and the teat, although the effect is reduced if the liner mouthpiece is thinner or softer. This same problem occurs if teat cups creep up too far on the teat.

Liners with a large diameter mouthpiece are more likely to slip, especially on cows with narrow teats.

### Mouthpiece depth

For cows with very short teats, eg. some heifers, the excessive depth of some liner mouthpieces leads to failure of the pulsation effect. The teats may swell inside the mouthpiece cavity or become pinched at the end and the cow may not be milked out properly, leading to cow discomfort, teat damage and possible new infections.

### Liner slip

Liner slips cause the sudden admission of air to a milking system and are implicated in mastitis transfer although the mechanism is unclear. Dragging clusters off without first having allowed the vacuum to fall in the claw is a similar event, causing back-jetting and considerable discomfort to the cow.

Well-fitting liners may improve milk yields by up to 7%, reduce milking time by up to 33%, and virtually eliminate strip yield and liner slip.

### Causes of liner slip

The following can influence the amount of liner slip:

- **Unsuitable choice of liner.** Select a liner to suit your herd. Surprisingly, unless cows have come from a variety of sources, teat sizes and particularly teat diameter in a herd are quite uniform. Finding a best-fit liner is relatively straightforward.
- **Incorrect vacuum levels.** Maintain vacuum levels in the proper range for your milking system.  
Although liner slip is most likely to affect the individual cow, liner slips also result in an unstable vacuum throughout the milking machine, which increases milker irritation and affects other cows being milked.
- **Inadequate vacuum pump capacity and line sizes, excessive system leaks, long and sagging milk tubes.** Be sure all components of your milking system are properly sized.
- **Poor regulator response.** An insensitive vacuum regulator can result in extreme vacuum fluctuations. Keep your regulator clean.
- **Poor cluster alignment.** Keep the cluster well aligned with the udder to ensure a good seal between the teat and liner. The claw should sit squarely under the udder. If clusters are more than about 1/3 of a cow out of line, they will twist and pull on the teats and cause uneven milking. Re-plumb the system if this is the case.
- **Twisted liners.** Liners that are twisted inside the shell prevent the teat from entering the liner properly, resulting in a poor vacuum seal. Make sure that the index marks on the liner head and short milk tube stay aligned.
- **Light quarters.** Light quarters often cause air leaks between the teat and liner. Since most light quarters are the result of previous mastitis problems in that quarter, the possibility of infection in that quarter and cow is above average.
- **Weight of cluster.** Check that the weight of the cluster is not too great to be supported by relatively small-teated cows.

Overall, the match of cow, liner and claw is important for fast, efficient and gentle milking.

### Recommendations for liner slip

- Keep milklines as low as practical.
- Shorten the stainless steel part of the long milk tube to end about 500 – 600 mm above the cow platform.
- Shorten the long milk rubber so that it doesn't sag and the cluster hangs on the cow evenly. Don't make it so short that it pulls the cluster out of alignment.
- If necessary alter the milkline position so that the clusters are aligned to the cow and the claw hangs on the udder without twisting.



***Fix poor cluster alignment to get faster, more efficient milking***

### The 'best' liner

The milking characteristics of liners are so variable that it is hard to generalise. Choose the best liner for your herd firstly on the basis of advice from a specialist, and then by trial and error. The best liner is the one that leaves the teats in the best condition, milks the fastest, milks quickly and cleanly, and slips the least during milking. (Liner slip may be due to causes other than liner design, so advice from a specialist is preferable).

The liners must be compatible with the shells used. Approved milking machine testers (Milking and Pumping Trade Association – MPTA) and liner retailers have information on liner/shell compatibility.

### Liner life

How long liners last depends on how they are used and cleaned. They must retain tension to give a proper squeeze, be smooth inside to limit the number of bacteria present, retain shape to prevent slip, and give consistent milking performance – a very difficult task.

Most manufacturers recommend using liners for a maximum of 2500 individual cow milkings. This means only 4 months twice daily milking for a 200 cow herd milked with 20 clusters.

As liners are used and exposed to cleaning agents they develop hairline cracks and become rough. Bacteria happily live and multiply in the cracks, and may cause mastitis and down-graded milk quality.

## Liner care

Most liners are now made from synthetic rubber compounds to minimise the absorption of fat. Even so, a good cleaning system with regular hot alkaline washes will prolong their life. At the end of the season removing the liners from the shells, cleaning them with a hot strong alkaline detergent, and storing them in a cool dark place in the dry period will also help to extend their effective life.

## Milking machine testing and servicing

Have a skilled tester test the milking machine twice a year. The first is a thorough check of all components and the second a quick check of the pulsators, vacuum level and reserve vacuum pump capacity.



If there is a problem, get a specialist to give the machine an intensive check. It's the only way to be confident that the milking machine is working well. A milking machine test is like a WOF for a car. It doesn't stop all accidents but gives more confidence that the main parts are working as they should.

- Make sure the tester you use is qualified, and holds a current practising certificate issued by the Milking and Pumping Trade Association (MPTA).
- Promptly fix any faults found.

## Checks you can do

- **Check pulsators.** You can tell a faulty pulsator by sound or by putting your thumb inside a liner under vacuum. The liner should close around the end of your thumb if the pulsator is working correctly.
- **Pay special attention to the heifers.** Have a little sympathy for heifers with their tiny teats. Look at them after milking. Are they blue, swollen, cracked, or with sores on the end or side? Two main possibilities are high vacuum level or unsuitable liners.
- **Check vacuum levels.** Prolonged exposure to high vacuum may damage teats, and will often result in blackspot.  
2 x 2 pulsation (where two liners collapse at the same time followed by the other two), tends to even out the milk flow from the claw. This makes the average vacuum under the teat 2 to 3 kPa higher than with a 4 x 0 pulsator (where all four liners collapse at the same time), making damage more likely. It therefore pays to set the vacuum level lower, especially at the start of the season when cows' teats are soft. The same applies to a low line machine when milking is very fast, even at say 45 kPa.
- **Check the effective reserve air.** The vacuum regulator, during milking with all clusters on, should hiss steadily as it lets in air. Effective reserve air is low if the vacuum level takes longer than a few seconds to recover to full vacuum after a cluster falls off a cow.
- **Listen for squeaky cups.** Liner slip causes mastitis transfer. Count the number of slips as indicated by squeaky cups. If there are more than 5/100 cows, apart from those on cows with obviously uneven quarters, it's worth checking to find the cause.
- **Check the milkline.** A very high milkline can lead to a succession of problems, including liner slip, slow and incomplete milking, and teat damage. Check that the fall is even and towards the receiver, and that the inlets enter the top half of the milkline.  
Milk flowing into the receiver in plugs indicates that the milkline diameter is too small for the number of clusters.
- **Check the alignment of the long milk rubbers.** They should hang evenly and not sag into the pit. Poor alignment with the cow leads to uneven and/or incomplete milking out of quarters.

## Checklists

The following list itemises the regular maintenance you can perform on your milking machine to keep it operating properly.

### Daily

- Listen to pulsators
- Correct faults
- Look for unsettled cows

### Weekly

- Check liners and pulse tubes for splits
- Straighten liners in the shells
- Clear air admission holes
- Check for teat damage
- Check regulator (should hiss with all cows milking)

### Monthly

- Clean pulsator filters
- Test liner tension (ie. the shell is roughly 5 – 10% longer than the liner where it contacts the shell)
- Test for liner collapse
- Check vacuum level
- Clean regulator
- Check milking line slope and inlet alignment
- Check vacuum pump drive belt tension and oiler rate
- Adjust rubber V belts
- Fix any leaks
- Count liner slips (max 5/100 cows)
- Test vacuum recovery (max 3 seconds from 40 to 50 kPa after an open tap is closed)

## Progress – or lack of it!

The response to well-implemented mastitis control programmes can vary, with some farmers making better progress than others.

No progress suggests a serious breakdown. With specialist help, reappraise machine efficiency and design, milking procedure, lactation and dry cow treatment strategies, the effectiveness of teat spraying, culling policy and animal management.

## Further advice

For further advice about mastitis control, contact

- Your Veterinarian.
- Your MAF Quality or other Management Specialist.
- Your milk processing company Quality Control Officer.
- Your Farm Consultant



# References

- Eden M.** *Managing Mastitis – a practical guide for NZ dairy farmers.* A Livestock Improvement publication. 1992.
- Holdaway RJ.** Further investigations of methods for the diagnosis of subclinical bovine mastitis. Report to the NZ Mastitis Council. 1990;196.
- Lacy-Hulbert J.** SMM Monthly Mastitis Focus. *New Zealand Dairy Exporter.* 1999;60.
- Lam TJGM.** *Dynamics of Bovine Mastitis.* PhD Thesis Utrecht; The Netherlands, 1996.
- Macmillan KL, Duirs GF, Duganzich DM.** Association between dry cow therapy, clinical mastitis, and somatic cell count score with milk and fat production in ten New Zealand dairy herds. *Journal of Dairy Science.* 1983;66:259-65.
- McDougall S.** Prevalence of clinical mastitis in 38 Waikato dairy herds in early lactation. *New Zealand Veterinary Journal.* 1999;47:143-9.
- McDougall S and Beal R.** *Practical mastitis workshop.* The Society of Dairy Cattle Veterinarians. 2000.
- Mein GA, Brown MR, Williams DM.** Pulsation failure as a consequence of milking with short teatcup liners. *Journal of Dairy Research.* 1983;50:249-258.
- Pankey JW and Watts JL.** Evaluation of spray application of postmilking teat sanitizer. *Journal of Dairy Science.* 1983;66:355-8.
- Pankey JW, Pankey PB, Barker RM, Williamson JH, Woolford MW.** The prevalence of intramammary infections in primiparous heifers in eleven Waikato herds. *New Zealand Veterinary Journal.* 1996;44:41-4.
- Philpot WN and Nickerson SC.** *Mastitis: Counter Attack.* 1991. Babson Bros. Co., Illinois 60563 USA.
- Radostits OM, Leslie KE, Fetrow J.** *Herd Health, Food Animal Production Medicine.* Philadelphia, USA: W.B. Saunders; 1996.
- Williamson JH, Woolford MW, Day AM.** The prophylactic effect of a dry-cow antibiotic against *Streptococcus uberis*. *New Zealand Veterinary Journal.* 1995;43:228-234.
- Woolford MW, Williamson JH, Copeman PJA, Napper AR, Phillips DSM, Uljee EJ.** The effect of mastitis on production in the following lactation. Ruakura Dairy Farmers' Conference. 1984;29-33.
- Woolford MW.** Mastitis in New Zealand. Where are we at and where are we going? *Proc. Second Inter. Conf. for the Soc. of Dairy Cattle Vet. of the NZ Vet. Assoc.* 1997;1-14.
- Woolford MW, Williamson JH, Day AM, Copeman PJA.** The prophylactic effect of a teat sealer on bovine mastitis during the dry period and the following lactation. *New Zealand Veterinary Journal.* 1998;46:12-19.
- Woolford MW, Williamson JH, Lacy-Hulbert SJ.** New aspects of prophylactic antibiotic use in dairy herds at drying off. *Vetscript.* 1999; 14-15.



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