9 Manage teat sores and cracks

The physical condition of the bovine teat is an indicator of the quality of the environment, the milking management and milking system used on a dairy herd and can also be used as an indicator for the risk of intramammary infections.

Mastitis risk is a numbers game – greater numbers of bacteria near the teat end increase the risk of infections occurring. Teat sores and cracks provide sites where bacteria can multiply. They can be painful to the cow, causing her to kick and defecate more frequently during milking time, and have incomplete let-down.

Healthy skin is easier to keep clean. Healthy teat skin is an indicator of gentle milking which is one of the aims of machine milking.

Keratin is a waxy substance produced by the cells lining the teat canal. It serves as a temporary seal between milkings and a more permanent plug throughout the dry period. Keratin is also a major structural component in skin, hair, nails and hoof cells.

Defence mechanisms of the teat canal

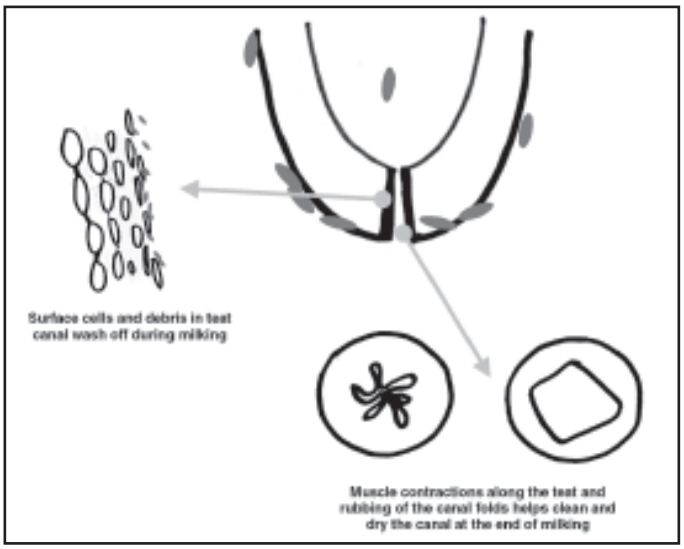
Mastitis occurs when bacteria enter the mammary gland via the teat canal. There are four physical mechanisms of the teat end and teat canal that protect against bacterial invasion. These are: :

- Tight closure and effective sealing of the teat canal between milkings;
- Adherence of bacteria to the keratin lining of the teat canal, between milkings;
- Shearing of the keratin lining during milk flow; and
- Drying and re-sealing of the canal lumen with the keratin during the early post-milking period.

Disruptions to any of these increase the susceptibility of the quarter to infection.

The teat canal is lined by a modified skin layer (epithelium) that is continuous with the outer teat skin but thicker. Typically, the canal is about 10–12 millimetres long. When opened, the circumference of the milk contact surface is about 6 millimetres. When closed in the inter-milking period, the canal is folded in an inter-digitated pattern.

Defence mechanisms of the teat end



Based on a recent study in a large, automatic milking herd in a free-stall housing system, it is likely that high quarter peak milk flow rates present only a small (or negligible) risk for new intramammary infection (Penry** et al**. 2017).

A common question asked of advisers is 'what is the acceptable time limit from teat cup removal to application of teat disinfectant?' This is not well described in studies but it makes sense based on knowledge of teat canal re-folding for application to occur as soon as possible after cups-off: minimising this time increases the chance of disinfectant perfusing through the milk column remaining in the teat canal as re-folding commences.

The teat canal provides the first and most important barrier to bacteria entering a quarter. The new infection risk is increased if:

- The teat canal is shorter than average (Lacy-Hulbert 1998).
- The keratin that fills the lumen of the teat canal does not seal the canal effectively in the inter-milking period or during the dry period. For example, incomplete sealing of the keratin plug was linked with higher new infection rate in the dry period (Williamson *et al* 1995). During lactation, high bacterial challenges led to higher infection rates if keratin was removed from the teat canal by reaming (Capuco *et al* 1992).

Previously, quarters with high peak milk flow rate were thought to be associated with increased new infection risk. In a bacterial challenge experiment, increased new infection rate was observed with increased teat canal cross sectional area during milking and high peak milk flow rates (Grindal and Hillerton 1991). However, no association was found with high peak milk flow rates and clinical mastitis in naturally occurring infections (Penry *et al* 2017).

The defence mechanisms that resist bacterial penetration through the teat canal are primarily physical in action (Williams 1984, Williams and Mein 1985, Lacy- Hulbert 1998). At a microscopic level they involve:

- Formation of a lipid film in mature keratin layers that allows trapping of bacteria and cleaning of the teat canal during milking or suckling; and
- Effective re-sealing of the folded canal when milking or suckling ceases.

Mature keratin cells are held loosely together in this film of lipid and bacteria that enter the canal stick to these cells. During milking, the action of pulsation and the shear force provided by milk flow through the teat canal wash away a high proportion of the mature keratin cells and any adherent bacteria. This flushing action has the effect of cleaning the teat canal surface. The lipid film is continuously replenished by the keratin cells lining the canal.

Technote 9
Teat sores

For the teat canal to effectively seal at the end of milking it must have a clean surface, free of cell debris and milk. When the teat cups are removed, waves of muscle contraction occur in the teat. The continuous film of milk lining the teat canal surface is disrupted by the 'wringing' action of this muscle contraction (passing from the base of the teat to its apex) and squeezing between the folds of the teat canal lining. The absence of a continuous column of milk within the canal prevents movement of bacteria by capillary action along the canal and stops their migration from the teat orifice to the teat cistern. The external teat orifice is then dried by ambient air assisting this natural defence mechanism. The presence of teat disinfectant in the milk film while it changes from a continuous column to a disrupted one enhances the natural defence mechanisms by providing a chemical barrier to bacterial migration.

These physical mechanisms operating within the teat canal have many practical and interesting consequences. For example:

- The milk stream associated with normal milking vacuum levels (about seven metres per second in the milk phase of the pulsation cycle in a correctly functioning machine) provides sufficient force to clean the lining of the teat canal by shearing the outermost layer of mature keratin cells, removing debris in the canal.
- Pulsation causes an action in the teat canal analogous to cleaning hands by rubbing them together under a tap. A cyclical pressure, applied by the liner collapsing around the teat apex at regular intervals, physically loosens debris that is flushed away during the next pulsation cycle. Capuco *et al* (1994) found nearly 40% of the mature keratin cells were removed at every milking by the combined effects of milk flow and pulsation compared with an average loss of about 25% in the absence of pulsation.
- The ability of the teat canal to trap bacteria is markedly reduced if keratin turnover and mature keratin removal within the teat lining is not maintained during an individual milking. Milking without pulsation in post-milking challenge experiments leads to very high new infection rates. A possible explanation for this is that the lining of the teat canal is still dirty (with mature keratin cells and surface debris) at the end of milking.
- Up to five million non-specific bacteria-sized particles (including bacteria) can adhere to the surface of an average-size teat canal before it becomes overloaded. Overloading can occur when teats are challenged with high environmental loads. For instance, dried manure bedding in barns in conditions of high humidity can contribute 10–100 million colony-forming units of Escherichia coli per milligram.
- Bacteria cannot move towards the udder cistern if only small, isolated spots of milk remain on the teat canal lining after it has been 'wrung dry'. Bacteria, however, are often found in these 'lakes' and species such as Strep agalactiae, Staph aureus and Corynebacterium bovis are capable of using teat canal lipid as a sole energy source to grow and divide. This reinforces the importance of a chemical barrier to bacterial proliferation provided by teat disinfectant applied immediately after teat cups are removed.

An implication of natural defence mechanisms is that reduced rates of new mastitis infections associated with more frequent milking are linked with more regular flushing and cleaning of the teat canal. This is supported by the typical observation that a shift to once a day milking increases individual cow cell counts. The exact mechanism behind this is unclear although it may be associated with a decrease in milk production seen with once a day milking.

Conversely, one of the main reasons for a higher infection risk in the early dry period is the absence of a mechanism for regular removal of pathogens adhering to the surface cells of the teat canals. Readers wanting more detail on the function of the teat canal are advised to read the comprehensive 2005 review paper by Paulrud.

Confidence – High

Maintenance of healthy teat skin is a key requirement for an effective mastitis program.

Research priority – Moderate

International agreement on teat evaluation methods was achieved in September 2001. Further analyses are required to refine current guidelines for interpretation of results. These include:

- thresholds of concern for different teat conditions; and
- the significance of 'No Ring' versus 'Smooth Ring' for teat end scoring.

Revised Technote 13 (February 2003) contains a Mastitis Investigation Pack with a recording sheet for teat condition (Sheet I).

9.1 Assess teat skin and teat ends every milking

Changes to teat tissue, particularly the skin of the barrel, teat end and teat canal, will alter udder defence systems. Veterinarians, field extension personnel, and farmers require a simple and reliable method for evaluating teat health in dairy herds. For farmers and advisers investigating possible problems identified by general observation of teats, it is important to have a method of qualitatively or quantitatively recording teat condition on a representative number of cows at standard milkings (Morgan 1999).

A protocol for systematic evaluation of teat condition in commercial herds, together with guidelines for interpretation of observations, has been developed by an informal discussion group of researchers and udder health advisers self-styled as the 'Teat Club International' (Mein *et al* 2001) and forms the basis of this Technote.

Various agents and mechanisms may affect the condition of the teats of the milking dairy cow. In general, these fall into one of three broad categories:

- Milking-induced (machines and management);
- Environmental; and
- Infectious.

The table below lists the main conditions in the first two categories.
For infectious conditions, see page 10

Table X Teat conditions arising from milking-induced and environmental effects in Australia

Milk-induced	Environmental
Discolouration	Skin dryness or roughness
Firmness or swelling	Hyperkeratosis
Wedging of the teat end	Chapping
Openness of the teat orifice	Abrasions and cuts
Petechial haemorrhages	Photosensitization
Hyperkeratosis (thickening of the teat end skin)	Chemical damage Allergic reactions Fly bites

Milking-induced or environmental changes

The relative influence of milking-induced or environmental factors affecting short-, medium- or longer-term changes in teat condition are reviewed briefly and discussed in this section.

Observations associated with short-term changes in teat condition

Short-term changes are generally regarded as those seen in response to a single milking. Faults in milking machines or milking management, or liner geometry (shape) are the primary cause of short-term effects such as changes in colour, firmness or swelling at the teat end or teat barrel, the degree of openness of the teat end and sensitivity to touch.

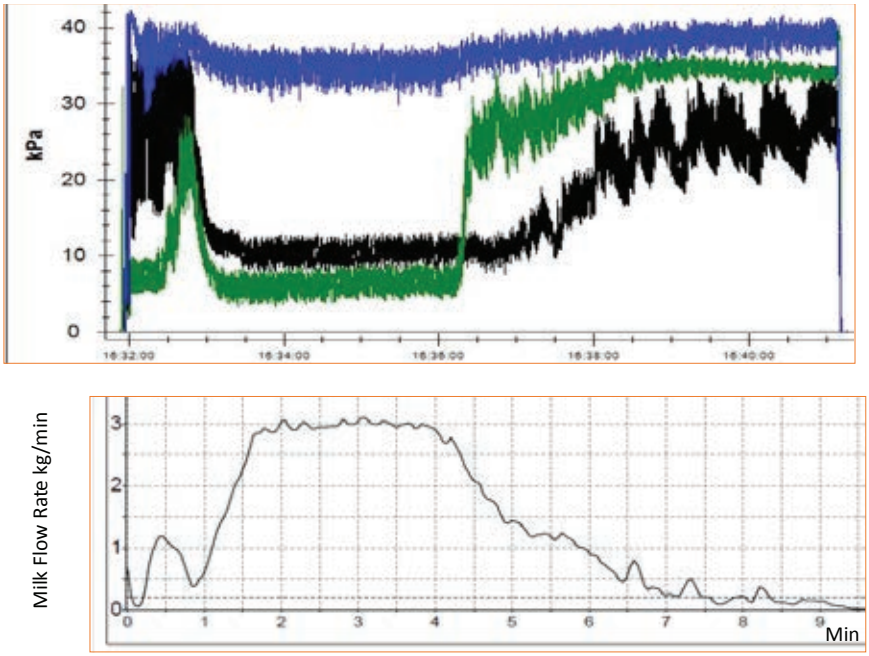
The short-term changes described largely indicate teat barrel or teat end tissue congestion. Congestion is defined as accumulation of fluid in the circulatory pathway. Oedema occurs when fluid accumulates in the interstitial spaces as a result of congestion. Observations from both research and commercial herds indicates that when congestion in teat tissue creates a 5% or more increase in tissue thickness, when post-milking size is compared with pre-milking size, there is an association with increased new infection rate (Mein *et al* 1986, Zecconi *et al* 1996) or individual cow cell count (Zwertvaegher *et al* 2013). However, the size of the effect on new infection rate, as a result of tissue congestion during milking, remains unclear. It is postulated that the biological mechanism leading to any increase in new infection is as a result of either increased teat canal closure time after cluster removal or direct impairment of teat end immune function (Paulrud 2005). Milking conditions that increase mouthpiece chamber vacuum, in the absence of high teat end vacuum, will lead to both teat barrel and teat end congestion (Penry *et al* 2017).

Confidence – High

Increased mouthpiece chamber vacuum during the peak milk flow period and the low flow period will induce teat barrel congestion.

Research priority – Moderate

Further field-based research is required to determine the lowest acceptable range of mouthpiece chamber vacuum which will reduce teat barrel congestion risk while not increasing the risk of cup slip.



Example of a VaDia vacuum recording showing mouthpiece chamber vacuum increasing at the start of the low flow period in 2 teat cups (green and black tracings). The blue tracing is short milk tube vacuum. The lower single black tracing is udder milk flow rate (adapted from Malmo and Mein, 2015).

Teat cup crawling occurs when a teat cup moves so far up the teat that the passage of milk from the udder to the teat is obstructed.

Colour changes

Some teats are noticeably red, either at the teat end or over the entire teat, when the cluster is removed. Others may become reddened within 30–60 seconds of cluster removal. In extreme cases, teats become blue or already appear blue when the cluster is removed. Abnormal teat colour observed after cluster removal and indicating circulatory changes as a result of milking, may be worse for short or slender teats because a greater proportion of the teat is in the mouthpiece chamber and hence not supported by the liner wall.

Reddish discolouration, indicating tissue congestion, with or without oedema, is exacerbated by over milking, (especially with wide-bore liners or tapered liners with wide upper barrels); unusually heavy cluster weight; high milking vacuum; faulty pulsation (very short d-phase, very long b-phase or both); or mismatch between the type of liner used and mean teat size within a herd. Bluish discolouration, indicating cyanosis, may result from use of liners with small mouthpiece diameter relative to the internal diameter of the barrel or liners mounted at unusually high tension. In many cases the liner geometry should be assessed for suitability of fit to the average teat length and width in an individual herd.

Although they are still subject to the same damaging influences, black teats and most pigmented teats must be excluded from any colour-based evaluation because these changes cannot be seen.

Colour changes are classified according to the proportion of light-coloured teats which, when examined within one minute of cluster removal, are:

- Normal – pink skin colouration.
- Red – part of or all the teat may be reddened.
- Blue – part of or all the teat appears to be tinged with blue or purple.

Because the causes of reddened or bluish teats may differ, red and blue classes should be recorded separately. However, analysis is simplified by combining these two changes into a single category ‘Red or Blue’.

Swelling at or near the teat base

When examined after milking, the upper part of the teat barrel may have a visible line or mark caused by contact with the liner mouthpiece lip, or visible swelling with a palpable, thickened ring. This occurs in the unsupported part of the teat that was inside the liner mouthpiece chamber near the end of milking. To avoid confusion with physiological swelling of teats and udders, cows with obvious signs of udder oedema or cows that calved within one week should not be evaluated.

Factors commonly responsible for swelling around the top of the teat as a direct result of milking include: high mouthpiece vacuum during the peak milk flow period associated with wide-bore liners; over-milking, especially with wide-bore liners or tapered liners with wide upper barrels; liners with a large mouthpiece chamber; teat cup crawling as a result of poor milk letdown; or liner mouthpiece lips that are unusually stiff or narrow in relation to teat size.

Swelling at or near the teat base when examined within one minute of cluster removal are classed as:

- Normal – no ring, little or no swelling, and teats that have a visible mouthpiece lip mark or ‘garter mark’ without palpable swelling (Hillerton *et al* 2000).
- Swollen – if there is marked swelling or palpable thickened ring.

Firmness at or near the teat end

Many teats feel soft and pliant after milking and they contract when touched. However, some teats feel swollen or firm or, in extreme cases, hard and unresponsive to touch. Factors commonly responsible for swelling near the teat end include: over-milking; use of wide-bore liners; high vacuum; pulsation failure (teats too short to reach the liner collapse zone during milking); or insufficient rest phase of pulsation (d-phase under 150ms).

Teats may look flat or wedge-shaped after milking. 'Wedging' describes the flattened shape of the teat end due to the compressive load applied by the opposing walls of a collapsed liner. Typically, this wedging will be slight. Severe wedging may result from: hard liners; liners mounted under high tension; a prolonged D-phase; or failure of the liners to open fully.

Teat ends are classified, by simple visual examination supported by manual palpation, as:

› Normal – soft and supple.

› Firm – firm, swollen or hard, or noticeably wedged.

Openness of the teat orifice

When examined immediately after milking, the external teat orifice may appear to be closed, slightly open or, in extreme cases, has a funnel-shaped opening about the size of a match-head. According to unpublished observations (cited in Mein *et al* 2001), both the new infection rate and the proportion of teats with open teat orifices were reduced in several mastitis problem herds in Australia, United Kingdom and United States following changes to milking equipment or procedures. Since 2001, there remains little published information on risk factors for open teat ends at cluster removal.

Factors linked with short-term, post-milking openness of the teat orifice include high milking vacuum, over-milking, unusually heavy cluster weight, or high liner mounting tension.

Teat orifices are classified by qualitative assessment within one minute of cluster removal as:

› Closed.

› Open – more than 2 millimetres wide or deep.

When estimating the degree of openness, it may be helpful to mentally compare the width and depth of an open orifice with that of a common object such as a match-head (typically about 3 millimetres in diameter) or the shaft of the match (about 2 millimetres). A clean paper towel or alcohol wipe may be needed to remove milk residue from the teat end to facilitate assessment. It should be stressed that inserting any part of a match into the teat end as part of this assessment should not be attempted for both hygiene and safety reasons.

Observations associated with medium-term or longer-term changes in teat condition

Medium-term changes in teat condition refer to tissue responses that take a few days or weeks to become visible, and often manifest as vascular damage or changes in teat skin or teat end condition.

Machine-induced haemorrhages of the teat skin (petechial or larger haemorrhages) may take several days to become evident.

Changes in teat skin condition associated with harsh weather or chemical irritation may take a few days or weeks to become visible. It typically takes 2–8 weeks for thickening of the skin (hyperkeratosis) at the teat end to develop. However, seasonal conditions can affect the dryness and hardness of keratin and teat ends of individual cows or herds are able to change within

days, especially in regions subject to harsh weather conditions (prolonged wet, cold and windy weather) or sudden weather changes. Teat end hyperkeratosis is sometimes also referred to as teat end callosity (Neijenhuis *et al* 2001) with the terms being interchangeable.

Skin condition

Healthy teat skin is coated with a protective mantle of fatty acids that slow the growth of bacterial pathogens.

In cold, wet and windy conditions, the skin of machine-milked teats often becomes scaly, irritated or chapped (broken) and the protective surface coating may be removed, allowing colonisation with pathogens such as Staph aureus. Cold, wet or muddy conditions also induce hardening or thickening of teat skin. Mud, as it dries, draws moisture from the skin with a consequent loss of elasticity and cracking of the teat skin. Machine milking exacerbates problems of chapping or cracking.

Chemical irritation associated with disinfectant type or concentration, or inappropriate type or concentration of emollients, may exacerbate the effects of harsh weather conditions and promote teat chapping. Skin conditioners or emollients either reduce evaporation from the skin or act as humectants (moisturisers) to maintain or improve the teat skin condition.

In the absence of cracks and sores, there is no distinguishable difference between dry and normal teat skin on new mastitis infection rates (Rasmussen and Larsen 1998). Teat skin condition is classified as:

- Normal – smooth sheen, soft, healthy skin.
- Dry – scaly, flaky or rough skin but with no cracking.
- Lesion – if there is any infectious or open lesion on the barrel or teat end, including chapped or cracked skin, and blackspot.

Vascular damage (haemorrhage)

The proportion of teats with evidence of petechial haemorrhages (or more extensive haemorrhaging) on their teats gives an indication of the presence and extent of vascular damage. Vascular damage usually reflects some type of pulsation failure often associated with high vacuum and/or prolonged over-milking. The incidence of vascular damage is lower in herds milked with narrow-bore liners, at low vacuum, and/or with automatic cluster removers.

Teat end hyperkeratosis

Teat end hyperkeratosis is a thickening of the skin of the teat end (giving roughness, cornification or callus formation of the stratum corneum). It is a dynamic condition.

Skin thickens in response to the forces applied to it. Just as the skin on a person's hands thickens in response to outdoor, manual work, so the skin of the teat end thickens in response to forces applied by the collapsing liner under pulsation during milking. All teats experience low milk flow periods at the beginning and end of each milking and teat end condition deteriorates when flow, at the quarter level, is less than 0.2kg per minute. More hyperkeratosis occurs with increased total time per milking below this milk flow rate. Environmental conditions such as protracted cold, low humidity and wet conditions can also increase the risk of hyperkeratosis.

The major factors affecting teat end hyperkeratosis are seasonal weather conditions, milking management and machine factors as summarised in table XX. The use of liners with high liner compression is a risk factor for hyperkeratosis as is elevated milking system vacuum resulting in high teat end vacuum even during the peak milk flow period (Reinemann 2013). Where overmilking is also a feature of milking management, in conjunction

Liner compression is the physical force applied by the liner to the teat-end during part of the c, all of the d and part of the a-phases of pulsation. It is a compressive pressure over and above the pressure of the air in the pulsation chamber. Overpressure is the pressure difference across the liner, as measured in the pulsation chamber, when milk just starts to flow during the a-phase of pulsation. Currently, no liners are sold with liner overpressure information available and so liner compression can only be estimated if advisers measure overpressure on farm

with either high liner compression or high teat end vacuum, hyperkeratosis risk will increase. Liner compression can be assessed by measuring a biologically relevant indicator, liner overpressure (Leonardi *et al* 2015).

Teat end hyperkeratosis may be exacerbated by disinfectants that cause chemical irritation to teat skin or may be improved by the use of a disinfectant with a high concentration of an effective emollient.

The Teat Club International notes that a small amount of teat end hyperkeratosis may be considered as a beneficial physiological response of the teat to machine milking whereas a greater degree of roughness is associated with an increased probability of new intramammary infections. Two multi herd studies have illustrated this association although they conflict on the severity of hyperkeratosis required to increase new clinical mastitis infection risk. A Dutch study (Neijenhuis *et al* 2001) found that small increases in hyperkeratosis score were associated with in increased risk of clinical mastitis between the 2nd and 5th month of lactation. In contrast, a UK study (Breen *et al* 2009) found that the risk of new Escherichia coli clinical mastitis was associated with moderate hyperkeratosis and the risk of new Streptococcus uberis associated with only severe hyperkeratosis.

An increased risk of subclinical mastitis also appears to be associated with hyperkeratosis. A recent study conducted on 9 US herds (Guarin *et al* 2017) found that the risk of quarter somatic cell count being in excess of 150,000 cells/ml was increased with a very rough teat end hyperkeratosis score although no trend was found with teats scoring rough (hyperkeratosis scoring method as described by Mein *et al* 2001). When viewed as a whole, it is clear that moderate to severe hyperkeratosis increases the risk of both clinical and subclinical mastitis, although, as with teat tissue congestion, the size of the effect remains unclear.

Table X Major risk factors affecting teat end hyperkeratosis

Risk factor	Reason for increased likelihood of teat end hyperkeratosis
Pointed teats	The load applied by the closing liner is on a smaller area of the teat surface
Increased age	The 'wrinkle factor' in all species
Higher production	Cups are on for longer
Peak lactation	Cups are on for longer
Udder washing	Water and chemicals reduce skin moisture and elasticity
Cups on before let down	Longer period of milk flow below one litre per minute
Low thresholds for Automatic Cluster removers (ACRs)	Longer period of milk flow below one litre per minute
Over-milking	Longer period of milk flow below one litre per minute
High vacuum	Greater stress on teat tissues - more stretched in the open liner and squeezed in the closer liner
Stiff liner mouthpiece	The lip acts like a tourniquet which slows or restricts outflow of blood from the teat wall when the liner is collapsed
Liners mounted at high tension	The region of greatest local pressure is applied just above rather than at the teat end This restricts outflow of blood from the teat tip (acts like squeezing a grape until the skin splits)
Liners with high liner compression	Reason for increased likelihood of teat end hyperkeratosis: high liner compression applies a greater physical force on the teat end during the collapse phase of pulsation

Confidence – High

Maintenance of optimal keratin turnover and healthy skin at the teat end is important for reducing bacterial load in the teat end environment.

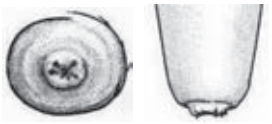
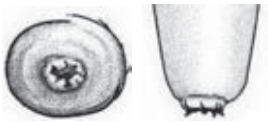
Research priority – Moderate

Published studies on the effect of teat end hyperkeratosis on new infections, as indicated by either clinical mastitis, or ICCC change, have all been based in Northern Hemisphere confinement dairy systems. Further research is required to define the nature of new infections, in pasture based dairy systems, associated with hyperkeratosis as classified in the Teat Club International system. More information is required on the size of the effect regarding new mastitis infections.

See the Countdown app for images of teat conditions

For routine field evaluation (in contrast to more detailed research observations), teat ends are scored as shown below.

Table X A scoring system for teat end hyperkeratosis (Mein *et al* 2001)

Score	Description	Illustration
N	**No ring** The teat end is smooth with a small, even orifice. This a typical status for many teats soon after the start of lactation.	
S	**Smooth or slightly rough ring** A raised ring encircles the orifice. The surface of the ring is smooth or it may feel slightly rough, but no fronds of old keratin are evident.	
R	**Rough ring** A raised, roughened ring with isolated fronds or mounds of old keratin extending 1-3 mm from the orifice.	
V	**Very rough ring** A raised ring with rough fronds or mounds of old keratin extending 4 mm or more from the orifice. The rim of the ring is rough and cracked, often giving the teat end a 'flowered' appearance.	

Teat conditions due to infectious agents

Infectious lesions of teat skin can indicate the standard of the general hygiene practices as well as mastitis prevention and milk quality management employed on the farm. Any deterioration of teat skin condition may adversely influence milk quality, milk safety, and udder health. Some may be hazardous to the health and safety of staff.

Viruses, bacteria, and fungi are responsible for most infectious lesions of teat skin and can affect the skin of the teat end, teat barrel or udder.

Viral infections of teat skin

Viral infections vary in their severity, infectivity and frequency of occurrence. Generally, they are rare in dairy farms where good udder hygiene is applied because most are readily controlled by minimising transmission via manual handling and also by use of post-milking teat disinfection.

Teat disinfection helps prevent viral infections even though most are not strong or specific enough to remove viruses. Many viruses require breaks in the skin to start infections. Application of post-milking disinfectants and emollients reduces the incidence of sores, rough skin, and cracks necessary for viral penetration and development.

Some exotic diseases cause lesions on teats (Geering *et al* 1995). Any unusual symptoms can be reported to the Emergency Animal Disease Watch Hotline on 1800 675 888.

Table X Viral infection of the teat

Viral infection	More information	Typical lesion
Pseudocowpox	'Pseudocowpox' FAQ sheet	Local, red angry lesions in the early stages that develop over a couple of days into small, raised, circumscribed lesions with dark red centres. A characteristic ring or 'horseshoe' shaped scab may be seen when crusts fall away. People are occasionally infected with purple 'milkers' nodules on their fingers.
Bovine herpes mamillitis	'Bovine herpes mamillitis' FAQ sheet	Numerous raised oedematous plaques about 1–2 centimetres in size. Lesions can cover a large part of the teat surface. The skin sloughs off leaving raw ulcers that are subsequently covered with dark coloured scabs.
Teat warts – papilloma	'Teat wart' FAQ sheet	Appearance varies with strain of virus from 'rice grain' in appearance, to fronds.
Foot and mouth disease (exotic)		The virus causes vesicular lesions and erosions on teats before they appear in the mouth.
Vesicular stomatitis (exotic)		Lesions similar to, and need to be differentiated from, foot and mouth disease.

Revised Technote 7 (February 2003) describes the characteristics of effective teat disinfectants and emollients.

Bacterial infections of teat skin

Bacteria may cause primary lesions or colonise the sites of existing lesions arising from machine-induced damage, environmental factors or viral infections.

Staph aureus, Strep dysgalactiae and Trueperella pyogenes are ubiquitous on the skin of dairy cows. These bacterial infections of teat skin are a major source of new intramammary infections and clinical mastitis, both in lactating and non-lactating cows. It was shown clearly some 30 years ago that chapped teats were highly likely to be infected with Staph aureus or Strep dysgalactiae, and that such infections were closely associated with high new infection rates and frequent cases of clinical mastitis (Kingwill *et al* 1970).

Disinfectants developed for teat treatment are usually effective at eliminating bacteria from lesions and often contain emollients to promote skin healing. The requirement to disinfect all teats of all cows after every milking, as part of mastitis control, is directed at reducing the exposure of the mammary gland to these organisms and to expedite rapid healing of all lesions.

One particularly important bacterial lesion, often associated with poor machine milking, is colonisation of the damaged teat orifice by Fusiformis necrophorum. This condition is known as blackspot and is easily recognisable from the colour of the scab formed. Bacteria erode the teat end and the orifice may become blocked, leading to incomplete and very slow milking. Blackspot is a major risk factor to intramammary infection by other bacteria. Milking conditions associated with an increased risk of hyperkeratosis also increase the risk of blackspot.

Bacterial infections of the teat

Bacterial infection	More information	Typical lesion
Staph aureus, *Strep dysgalactiae*, *A. pyogenes*		Primary bacterial infections present as pustules. They may be necrotising, especially when Staph aureus is involved. Secondary bacterial infections may cause significant changes in the appearance of other lesions, making diagnosis difficult.
Blackspot – *Fusiformis necrophorum*	Blackspot FAQ sheet	Lesions look like craters with raised edges and have a black spot of ulceration or scab in the centre. They often involve the teat end.

Revised Technote 13 (February 2003) contains a Mastitis Investigation Pack with a recording sheet for teat condition (Sheet I).

Fungal infections of the teat skin

Infection of skin keratin by the fungus Trichophyton spp. occasionally spreads to the teat. The condition is very unlikely to be confined to the teats and udder and should be easily recognised from the characteristic grey-white and ash-like skin encrustations.

The infection is highly contagious and may spread to milking staff. Usually herd immunity develops but reoccurrence is typical when new susceptible animals are introduced or animals are immune-stressed, especially as spores survive in the environment for several years.

Table X Fungal infection of the teat

Bacterial infection	Typical lesion
Ringworm – Trichophyton spp.	A characteristic grey-white encrustation. The infection may spread to milking staff

Systematic evaluation of teat condition in commercial herds

Deciding how many teats to observe

Perhaps the most common weakness of teat evaluation procedures in commercial herds is that sample sizes are too small (Reinemann *et al* 2001).

A guide to initial sample size is:

- In herds of up to 400 cows, assess all teats on at least 80 randomly selected cows to represent 20% or more of the herd.
- In herds of more than 400 cows, assess all teats on at least 20% of the herd with cows randomly selected.

Sampling more cows will increase the accuracy of the diagnosis relative to trigger levels described for teat conditions (such as hyperkeratosis).

Try and make your sample representative of the herd. The main source of error is probably milking order. The first 50 cows that are milked may be a very different cohort than the last 50.

Making the observations

To simplify and streamline the procedure, teat condition should be evaluated immediately after the cluster is removed and before application of a teat disinfectant. However, if an observer wants or needs to assess skin changes in greater detail, it will be necessary to check skin condition before milking. Practical tips to making teat observations are:

- Exercise great care when approaching cows and handling teats – especially in herds where cows are not used to having their teats touched.
- Observe and record teats in a regular pattern.
- View the teats, initially, without handling.
- Dry the teat end with a disposable paper towel if milk residue or debris obscures the view of the orifice.
- View teats by gently grasping the teat above the teat end. Observe the teat from side on and then from end on. Good lighting is essential. If lighting is poor, use a headlamp rather than a flashlight for hands-free evaluation. This is important for increased work safety.
- To ensure confidence in the data, score a randomly selected, but representative sample of cows from all age groups or management groups.
- An automatic recording method, such as a dictaphone with a 'pause' button, enables a single observer to evaluate and record teats. (Note a voice-activated recorder is difficult to use successfully in the noisy environment of the farm dairy.) If two people are present, one can observe teats while the other records data.
- A digital camera offers an excellent way to capture typical or interesting teat conditions for subsequent discussions with the farmer or other udder health specialists.

If a single cow has two teats observed with Very Rough (VR) hyperkeratosis, then the score for this cow is VR. The recording method should capture and hence allow for further interpretation of two teats within this cow being affected.

Interpreting the results

When assessing teat changes, it is probable that in some cases, observations seen on one teat will increase the chance of the same observation being noted on another teat within the same cow. Hence, teat observations can be assumed to be, potentially, correlated within cow. As a result, it is recommended that observations are conducted at the cow, rather than quarter level. The score recorded for the most severely affected teat becomes the score for that cow. However, collecting information on the number of affected teats within a cow is useful as it provides data on the distribution of problem teat conditions among cows.

Countdown currently recommends further investigations of milking machine, management, environmental and infectious factors may be required if one or more of the following are observed:

- Colour: more than 20% of cows score one or more light-coloured teats that are visibly reddened (congested) or tinged with blue (cyanotic).
- Swelling at or near the top of the teat: more than 20% of cows score one or more teats with marked swelling or palpable rings.
- Firmness at or near the teat end: more than 20% of cows score one or more teats ends classified as firm, hard or swollen, or noticeably wedged.
- Openness of teat orifice: more than 20% of cows score one or more teat orifices classed as open.
- Vascular damage: more than 10% of cows score one or more light-coloured teats with petechiations.

Colour, swelling near the top of the teat, firmness near the teat end, openness of teat orifice and vascular damage are short to medium-term effects primarily associated with milking machine faults or poor milking management resulting in long periods of udder level low flow below 1 litre/minute and/or over milking.

- Teat skin condition: more than 5% of cows score one or more teats with open lesions (including chaps or cracks).
- Teat end hyperkeratosis: more than 20% cows score one or more teats as R or V, or more than 10% scored V.
- It is important to use the proportion of abnormalities observed in a sample of teats from the herd as a guide rather than an inflexible threshold. Any calculation made from a sample from a population is only an estimate of the population's actual value.
- If the observed result from the sample is:
- Below the range, there is no problem with the herd
- Above the range, there is a problem with the herd
- Within the range (inclusive of the end points), there may be a problem, with the higher the observed number, the more likely that there is a problem

In this third situation, it may be worthwhile examining more teats before making a final assessment of the situation – especially if additional problems (with the milking machine, milking system or other teat abnormalities) have been identified in the herd.

Table X Critical values for determining herd status from a survey

Sample size (number of cows examined)	Proportion of affected cows in the herd that makes it a problem herd		
	>20%	>10%	>5%
	Number of cows with at least one abnormal teat observed		
80	11–22	5–13	2–7
100	15–27	6–15	3–9
150	23–38	10–21	4–12
200	32–49	14–27	6–15
250	41–61	18–33	8–18

The above table is based on the 5th percentile and 95th percentile for a binomial distribution with prevalence equal to the threshold prevalence.

Using a sample to detect when the prevalence of teat abnormalities in herds is likely to be 10% or 20% (based on the binomial distribution)

If you observe … teats	And more than … have the abnormality	Then suspect at least …% of teats in the herd have the abnormality*
100	5	10
100	13	20
200	13	10
200	30	20
300	21	10
300	47	20
400	29	10
400	65	20

**The values in the second column show the lower limit of the 95% confidence interval for the herd proportion. For these figures to be valid, teats must be randomly selected from the herd and independent (when an abnormality is observed on one teat, other teats on the same udder should be no more or less likely to be affected).*

Based on recorded observations, a high proportion of cows may have the same teat affected. Alternatively, a high proportion of cows recorded with a teat condition may have 3–4 teats affected. These types of patterns can be very helpful indicators of a milking machine problem or a cow problem.

Technote 9
Teat sores

Some of the common primary causes or exacerbating influences for particular teat conditions are listed in the table below.

Table X Primary causes (1) or exacerbating influences (2) on teat condition induced by milking

	Teat colour	Swelling at teat base	Firmness/ hardness of teat end		Orifice
Observation	**Red/blue**	**'Ringing'**	**Hard**	**Wedged**	**Open**
Machine factors					
High milking vacuum	1	1	1		1
Faulty pulsation	1		1	1	
Short d-phase	1	1			
Long d-phase				1	
Liners*					
› Wide bore liner	2	2	2		
with tapered barrel		2			
› Aged (i.e. stiff or very pliable walls)	2				
› High tension* (i.e. stiff walled liner)	2			1	1
Mouthpiece					
› Deep chamber	2	2			
› Small diameter	2	2			
› Stiff mouthpiece		2	2		
› Poor liner-teat fit	2	2			2
Milking management					
Long dribble times (flow below 1L/min per cow)	1	1	1		
Overmilking (flow below 200 ml/min per cow)	1	1	1		1
Teat cup crawling	2	2	2		

** For more information on liner characteristics, see the 'Liners' advisors note.*

Teat skin condition and teat end hyperkeratosis are medium to longer-term effects primarily associated with poor environment, management or chemical irritation, or cow factors such as teat shape, yield and genetics. They are exacerbated by machine milking, especially if poor milking management results in over milking or prolonged milking at a low milk flow rate. Faults in milking equipment are unlikely to be primary causal factors if one or more of the short-term changes are not obvious.

Table X Primary causes (1) or exacerbating influences (2) on medium to long-term changes in teat condition induced by milking or environmental factors

Observation	Teat skin		Teat end
	Rough/scaly skin, cracks or lesions	Haemorrhages	Hyperkeratosis
	Medium-term	Medium-term	Medium-long term
Machine factors			
High milking vacuum		1	1
Faulty pulsation		1	
Liners*			
› Wide bore liner with tapered barrel		1	
› Aged (i.e. stiff or very pliable walls)		1	1
› High tension* (i.e. stiff walled liner)		1	1
› High liner compression			1
Milking management			
Long dribble times (flow below 1L/min per cow)			1
Overmilking (flow below 200 ml/min per cow)		2	1
Chemicals (or insufficient emollient)	1		2
Environmental factors			
Cold, wet, windy weather	1		2
Mud/manure (e.g. from intensively grazed or stand-off areas)	1		
Sunburn or forage-related photosensitisation	1		
Infectious skin lesions	1		

** For more information on liner characteristics, see the 'Liners' advisors note.*

These tables are intended as an initial guide only. It is rare for a single factor to be the sole contributing cause. Furthermore, some of the factors are inter-dependent (for example, higher vacuum may induce longer dribble times and/or more overmilking). Therefore, the table should be interpreted in conjunction with the results of other milking-time tests and observations using the combined experience of all the members of the investigating team.

9.2 Reduce mud problems by maintaining clean, dry trough areas, farm tracks, laneways, gates, and entrances and exits to the shed

&

9.3 Ensure cows don't have access to creeks, dams and watercourses

TN 27 discusses ways to fix areas that make udders muddy

Sheet G in the Countdown Mastitis Investigation Pack is used to record teat and udder condition prior to teat cup attachment. This observation set can be assisted by the pre-milking udder hygiene chart developed by Schreiner and Ruegg (2003) where udders are assessed on a scale of 1 to 4 with 1 being free of dirt and 4 being grossly contaminated with caked on dirt covering more than 30% of the surface area. Udders with scores 3 or 4 have a higher risk of mastitis compared to udders with scores 1 or 2. A 20% trigger point for the proportion of udders scoring 3 or 4 was proposed by Schreiner and Ruegg. Observations indicating this trigger is exceeded can initiate a review of pre-milking, paddock and track hygiene. The 8-herd study conducted by Breen *et al* (2009) supported the association between cows with very dirty udders and the risk of clinical mastitis.

9.4 Minimise use of water on cows in the dairy

TN 5.3 discusses udder cleanliness and pre-milking preparation

9.5 Check teat disinfectant mix, particularly emollient concentrations

Revise TN 7.5 (Feb 2003) discusses how to maintain teat condition using emollients.

9.6 Check important machine factors

TN 6 describes how to monitor and maintain milking machine function.

9.7 Avoid the use of teat ointments, especially those that come in tubs or jars.

Ointments used to improve teat health and condition may have the opposite effect by:

- Increasing teat cup 'crawl'. In one study of the effects of greasing teats, the average strippings yield at the end of milking was trebled when all the regions of contact between the teat and liner were lubricated to reduce friction (Mein *et al* 1973).
- Exposing the teat end to bacteria. Teat ointments that are dispensed by hands repeatedly dipping into a jar become easily contaminated with environmental bacteria.
- Prolonging the contact time of bacteria on the teat.
- It is easier to avoid using teat ointments rather than to work around these issues. However, if teat ointments are used:
- Choose one of the newer varieties of ointments containing a base such as sorbolene or glycerol rather than the oily/grease type products;
- Choose a dispensing container that maintains a clean reservoir of product, for example pump jars that dispense a single dose of product; and
- Apply them only at the end of milking.

Advisers and farmers should also be aware that a number of teat ointments contain Nonyl-Phenol Ethoxylates or Quaternary Ammonium Compounds which are now prohibited residues for most milk companies.

The Mastitis Investigation Pack in the revised Technote 13 (February 2003) provides a systematic approach to investigating problems.

9.8 Seek advice from your veterinarian if problems persist

Farmers are urged to seek advice from a Countdown trained adviser if problems are identified with teat condition.

Many farmers, especially those who have participated in Countdown farmer extension activities or use the Countdown app, use triggers to identify when their milking system is not operating properly – including assessment of teat condition. Farmer assessment of teat condition covers the same range as described in this Technote, alerting them to changes in teat skin colour, swelling, hardness and teat ends. However, it is the adviser's role to investigate these alerts, including a thorough teat assessment, to better understand the situation.

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