Maintenance of healthy teat skin is a key requirement for an effective mastitis control programme. The physical condition of the bovine teat is an indicator of the quality of the environment, the milking management and the 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 – more bacteria near the teat end increase the risk of new 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, and have poor let-down.

Healthy, undamaged skin is easier to keep clean.

**Defence mechanisms of the teat canal**

Mastitis occurs when bacteria enter the mammary gland, usually via the teat canal. There are four physical components 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;
- shearing of the keratin lining during milk flow; and
- drying and re-sealing of the canal lumen during the early post-milking period.

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

The teat canal is lined by a modified skin layer (epithelium) that is continuous with the outer teat skin. 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 highly folded.

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

- The effective diameter of the teat canal is relatively wide (as indicated by a higher peak milk flow rate from the teat). For example, teats with high milk flow rates had higher infection rates in...
the dry period (Dodd and Neave 1951), and similarly, higher infection rates during lactation in experiments involving artificially high bacterial challenge (Grindal and Hillerton 1991).

- The teat canal is shorter than average (Grindal et al 1991; Lacy-Hulbert and Hillerton, 1995).
- 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).

**Defence mechanisms of the teat end**

The defence mechanisms that resist bacterial penetration through the teat canal are primarily physical (Williams 1984, Williams and Mein 1985, Lacy-Hulbert and Hillerton, 1995, Lacy-Hulbert 1998). At a microscopic level they involve:

- formation of a lipid film in mature keratin layers that allows easy opening and cleaning of the teat canal during milking or suckling; and
- effective re-sealing of the canal when milking or suckling ceases.

Mature keratin cells are held loosely together in this film of lipid, and bacteria in the canal stick to these cells (see figure above). During milking, repeated compression by the pulsating liner and the flow of milk 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.

It is thought that, for the teat canal to effectively seal at the end of milking this lipid film must reform and bind the keratin cells together. When the teatcups are removed, waves of muscle contraction occur in the teat. The film of milk on 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 udder cistern. The external teat orifice is then dried by ambient air assisting this natural defence mechanism.

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 (moving at about seven metres per second in the initial pulsation cycle of 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 a proportion of the teat lining is not flushed away by the end of milking. Milking without pulsation in post-milking challenge experiments leads to an accumulation of keratin in the teat canal (Lacy-Hulbert et al 1996), and very high new infection rates. A possible explanation for this is that keratin, potentially contaminated with pathogenic bacteria, is retained for longer in the teat canal, providing a greater opportunity for these bacteria to enter the gland.
- The highly convoluted surface of the keratin, covered by the lipid film, provides a high capacity to absorb and entrap bacteria, especially those with a high degree of cell surface hydrophobicity such as Staph. aureus and Strep. dysgalactiae (Mamo et al 1987; Calvinho et al 1996). This may support their ability to colonise the teat canal prior to gaining access into the gland.
- Bacteria cannot move towards the udder cistern if only small, isolated spots of milk remain on the teat canal lining after it has been ‘wring dry’. Most mastitis-causing pathogens are non-motile and require the random movement of milk through the teat canal to transport them through the teat canal. Resealing, and mild dehydration of the keratin material between milkings, helps prevent movement of this milk film through the teat canal. Certain bacteria, such as Strep. agalactiae, Staph. aureus and Corynebacterium bovis, may collect specifically in these isolated spots of milk, and make use of the teat canal lipid film and milk as energy and protein sources to grow and divide.
9.1

Assess teat skin and teat ends systematically.

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 to qualitatively or quantitatively record teat condition on a representative number of cows at milking time (Ohnstad 2010).

A protocol for systematic evaluation of teat condition in commercial herds, with guidelines for interpretation of observations, was developed by an informal discussion group of researchers and udder health advisers known as the ‘Teat Club International’ (Mein et al. 2001; Hillerton et al. 2001). Another, more recent paper (Ohnstad et al. 2007) provided guidelines on:

- Effective treatments and changes in management or machine settings that appear to provide successful solutions for teat condition problems in commercial herds;
- The expected time scale - after the start of a successful treatment or management change - until improvements in teat condition should become evident;
- The estimated level of confidence for each recommendation or conclusion.

The series of guidelines in these three Teat Club papers form 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.

Table 1 lists the main conditions in the first two categories. For infectious conditions, see section C below (page 14).

Table 1. Teat conditions arising from milking-induced and environmental effects in Australia and New Zealand.

<table>
<thead>
<tr>
<th>Milking-induced</th>
<th>Environmental</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discolouration</td>
<td>Skin dryness and chapping</td>
</tr>
<tr>
<td>Firmness or swelling</td>
<td>Teat orifice roughness and hyperkeratosis</td>
</tr>
<tr>
<td>Wedging of the teat end</td>
<td>Abrasions and cuts</td>
</tr>
<tr>
<td>Openness of the teat orifice</td>
<td>Photosensitisation, sunburn, frostbite</td>
</tr>
<tr>
<td>Petechial haemorrhages</td>
<td>Chemical damage</td>
</tr>
<tr>
<td>Hyperkeratosis (thickening of the skin at the teat orifice)</td>
<td>Allergic reactions</td>
</tr>
<tr>
<td></td>
<td>Insect bites</td>
</tr>
</tbody>
</table>
A. Short-term, milking-induced changes in teat condition

Short-term changes are generally regarded as those seen in response to a single milking. Faults in milking management or milking machines are the primary cause of short-term effects such as:

- discolouration - that is, reddened, bluish, purplish or very white teats seen immediately after milking;
- firmness or swelling of the teat or “ringing” around the upper teat barrel;
- wedging of the teat end;
- degree of openness of the teat orifice.

Some specific causes, or exacerbating influences, on these teat conditions are summarised in Table 2.

Generally the teat takes some hours to recover its full integrity even from good milking conditions (Neijenhuis et al. 2001b). However, improvements in teat condition should be evident immediately after the milking at which the specific fault or faults have been correctly identified and fixed. Full rectification may take one or more days.

Table 2. Primary causes (1) or exacerbating influences (2) on short-term changes in teat condition induced by milking.

<table>
<thead>
<tr>
<th>Observation</th>
<th>Teat colour</th>
<th>Swelling at teat base</th>
<th>Firmness/hardness of teat end</th>
<th>Orifice</th>
</tr>
</thead>
<tbody>
<tr>
<td>Machine factors</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High milking vacuum</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Faulty pulsation</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Short d-phase</td>
<td>1</td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Long d-phase</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Liners*:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Wide bore liner with tapered barrel</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>- Aged (i.e. stiff or very pliable walls)</td>
<td>2</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- High tension (i.e. stiff walled liner)</td>
<td>2</td>
<td></td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Mouthpiece:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Deep chamber</td>
<td>2</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Small diameter</td>
<td>2</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Stiff mouthpiece</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mismatch of liner and teats</td>
<td>2</td>
<td>2</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Milking management</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Long dribble times (flow below 1L/min per cow)</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Overmilking (flow below 200 ml/min per cow)</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Teatcup crawling</td>
<td>2</td>
<td>2</td>
<td></td>
<td>2</td>
</tr>
</tbody>
</table>

* For more information on liner characteristics, see the ‘Liners’ Advisors Note.
Evaluating machine-induced, short-term changes

1. Colour changes

Some teats are noticeably red, either at the teat end or over the entire teat, when the cluster is removed. Others may initially appear white, and feel cold, and then become reddened within 30-60 seconds of cluster removal. In extreme cases, teats become blue or already appear blue when the cluster is removed. Poor teat colour after milking may be worse for short or slender teats, or highly oedematous teats, because they are supported less effectively by the liner.

Reddish discolouration, indicating congestion, 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; 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 a small mouthpiece diameter relative to the internal diameter of the barrel or liners mounted at unusually high tension.

Black teats and most pigmented teats must be excluded from colour-based evaluations 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.
- **Red** - part of, or the entire teat, may be reddened.
- **Blue** - part of, or the entire 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’.

2. Swelling at or near the teat base

When examined after milking, the upper part of the teat 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 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; teatcup crawling; 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 is classed as:

- **Normal** – no ring, little or no swelling, and teats that have a visible mouthpiece lip mark or ‘garter mark’ (Hillerton et al 2000).
- **Swollen** – if there is marked swelling or a palpable thickened ring.
3. Firmness at or near the teat end

Teats should feel soft and pliant after milking and contract when touched. However, some teats feel swollen or firm or, in extreme cases, hard, cold 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; or insufficient rest phase (d-phase) of pulsation.

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.

4. 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.

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). Flicking the teat end, or use of a clean paper towel may be needed to remove milk residue from the teat end to facilitate assessment.
B. Medium to long-term, milking induced or environmentally induced changes in teat condition

Medium-term changes refer to teat tissue changes that take a few days or weeks to become noticeable. Some specific causes, or exacerbating influences, on medium-term teat conditions are summarised in Table 3.

Medium-term changes in teat condition take longer to resolve than short-term changes. Some improvements should occur within a few milkings but, for others, significant improvement may take up to 4 weeks after correct identification of the fault and elimination of the cause.

**Table 3. Primary causes (1) or exacerbating influences (2) on medium to long-term changes in teat condition induced by milking or environmental factors.**

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

* For more information on liner characteristics, see the ‘Liners’ Advisor Note.

Confidence – Medium/High

Most problems occur with:
- poorly serviced and maintained equipment,
- over-milking,
- poorly set up installations.

Poor teat condition is more apparent after cluster removal.
Evaluating medium to long-term changes

1. Petechial haemorrhages

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

Vascular damage usually indicates some type of pulsation failure, or shortened d-phase, often associated with high vacuum and/or prolonged overmilking. If the damage is chronic it is more likely to result from prolonged over-milking (see Table 3). The incidence of vascular damage is lower in herds milked with narrow-bore liners, at low vacuum, and/or with automatic cluster removers.

This condition can be improved by correcting vacuum and/or pulsation settings to improve teat end massage during pulsation. Extreme care must be taken to ensure that vacuum and pulsation issues are considered in conjunction with cluster position and tube support. Where cluster position is poor, eliminating vacuum and/or pulsation faults may not provide a complete solution.

Some improvement should occur within a few milkings, but significant improvement may take up to 4 weeks after correct identification of the fault and elimination of the cause.

Petechial haemorrhages are classified by close examination of the teat end, according to their position and extent on light-coloured teats. Teats are scored as:

- **Normal** – no evidence of petechial haemorrhage
- **Mild** – Small pin-prick red spots in discrete areas or very diffuse across the teat end.
- **Moderate** – Dense red spots, affecting a discrete area.
- **Severe** – Spots or red marks coalescing into a bruise or sore with or without open lesions.

2. Teat skin condition - environmental changes

Healthy teat skin is coated with a protective mantle of fatty acids that slows the growth of bacterial pathogens. Teat damage causes this protective surface coating to be removed, allowing colonisation of pathogens such as *Staph. aureus*.

In cold, wet and windy conditions, the skin of machine-milked teats often becomes dry, rough or scaly. With time, the skin can become irritated and chapped (broken), which can lead to the formation of cracks. Weather changes can have an almost immediate effect on teat skin roughness, and teat skin and end cracking can occur within 1-2 days under severe winter weather changes (Timms, 2004). At moderate temperatures (-3 to 24°C) teat skin condition could be improved significantly over a period of 4 weeks through the use of a teat spray containing 8% emollient, compared to a spray containing only 2% emollient (Rasmussen and Hemling, 2002) in an automatic teat spraying system.

Cold, wet or muddy conditions can also induce hardening or thickening of the teat skin, possibly by reducing circulatory blood flow through the
tissues. Mud, as it dries, can also draw moisture from the skin with a consequent loss of elasticity of the teat skin. Hardening or thickening of the skin can lead to teat end hyperkeratosis (see below).

Poor teat skin condition is more apparent after cluster removal. Factors that exacerbate teat roughness and damage include:

- insufficient emollient in the teat disinfectant
- lack of teat spray coverage
- older style milking equipment
- poorly serviced and maintained milking equipment
- over-milking
- new installations lacking quality control of the machine set-up (Hillerton et al 2000; Hillerton et al 2002).

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.

### 3. Teat skin condition - chemical irritation

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 (Hemling 2002).

When teats were intentionally irritated with a harsh chemical (Fox 1992), the irritant effect was maximised after 1-3 days. Progressive healing from severe teat skin and teat end damage can take 3-5 weeks. More typical degrees of irritation resolve in 10-14 days (Rasmussen 2003).

Teat disinfectants more usually show an effect on teat barrel skin rather than on the teat ends. This is because the disinfectant and the environment are the major influences on the teat barrel, whereas the milking process has a more significant effect on the teat end. Skin thickness should not be affected by teat disinfectants although aggressive chemicals may induce a hyperplasia of the epidermis leading to thickened and scaly skin, which will resolve in 7-10 days with use of a milder disinfectant.

In a case study in the UK, teats were sprayed unintentionally with a concentrated, low pH, iodine-based, vat cleanser for three milkings (Ohnstad et al 2007). The burning of teats was severe and it took several weeks for the skin to return to visible normality. Further, many cows in the herd seemed to become sensitised to iodine products. Using a chlorhexidine formulation with a high concentration of glycerine successfully restored teat condition. However given the dominant use of iodine as the preferred teat disinfectant, sensitisation to iodine is not routinely observed.
The first generation of iodine-based teat disinfectants had a pH 1-2 and their irritant effect on teat skin was only partially ameliorated by emollients. More recent iodine-based disinfectant technologies have a pH of 3.5 or more, and produce little evidence of teat irritation with the appropriate use of emollient. Sensitivity is extremely rare. Chlorhexidine solutions are mild in most cases and unlikely to have an adverse effect on teat skin.

Classification of this condition is as described in section 2 above. Potential causes of chemical irritation can include:

- Use of an inappropriate chemical for teat disinfection e.g. use of milking plant sanitisers instead of teat disinfectant
- Use of an approved teat disinfectant product at too high a concentration

Improvements in teat skin roughness can be noticed almost immediately after elimination of the specific cause but reach an end point in improvement in 2-3 weeks (up to 5 weeks for more severe damage).

4. Teat skin conditions – photosensitisation

Skin damage or lesions due to photosensitisation are largely confined to non-pigmented hairless areas of skin exposed to sunlight and may, therefore, be evident on the outer surfaces of light-coloured teats of affected cows.

Primary photosensitisation usually occurs when photodynamic agents, mostly derived from plants, are retained in the bloodstream rather than being excreted at normal rates in the bile. Spring eczema is one example of this condition, which may be linked to the grazing of lush spring pasture.

Secondary or hepatogenous photosensitisation arises following damage to the liver, which limits its ability to clear chlorophyll break-down products, which are photodynamic, from the bloodstream. Common causes include ingestion of facial eczema spores, ingestion of blue-green algae, or grazing of certain plants (e.g. lantana, ragwort, lupins). For more information see “Diseases of Cattle in Australasia” by Parkinson et al (2010), pages 588-590.

Cows with early photosensitization of the teats may be restless and kick at their udders and abdomens, because the affected areas are very itchy. Affected skin becomes red and oedematous but changes may not be noticed until the top layers of skin die and become hard, dry and leathery, or sheets of dead skin flake off.

Treatment is by removal of the insults, shade from the sun and diet. Application of sun blocks, zinc oxide creams, or barrier creams can also help alleviate symptoms. If liver damage has occurred, this medical problem is the primary issue, with oral treatment with zinc oxide often recommended.

Light-coloured surfaces of teats can also be prone to sunburn, especially the front surfaces of widely-displaced front teats. This will show as redness of the skin and differs from the photosensitisation described above. Application of teat salves or sun blocks to the affected skin and improved coverage with teat spray will help prevent this condition from leading to mastitis. Classification of this condition is as described in section 2 above.
5. Teat end hyperkeratosis

Teat end hyperkeratosis is variously described as roughness, thickness, teat rings and fronds. It is a dynamic condition and is infrequent in heifers before calving, but common in machine milked animals (Sieber and Farnsworth 1981; Shearn and Hillerton 1995; Neijenhuis et al 2000). Once present it appears to vary little in response to milking management or other stimuli.

The amount of hyperkeratosis varies dynamically, increasing from calving to peak lactation and then decreasing towards the end of lactation. It also increases progressively with parity (Shearn and Hillerton 1996; Neijenhuis et al 2000). The extent of hyperkeratosis and the degree to which it can be improved is related to teat shape, being worse with long, slender or pointed teats. There may, therefore, be a genetic influence.

Teat end hyperkeratosis is often influenced by seasonal weather conditions (Table 4), with teats becoming more prone to developing hyperkeratosis when conditions are wet and cold, which may be mediated through reduced blood circulation.

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 milking and environmental effects.

All teats experience low milk flow periods at the beginning and end of each milking and teat end condition deteriorates when flow is less than one litre per minute. More hyperkeratosis occurs with increased total time per day below this milk flow rate.

The major factors affecting teat end hyperkeratosis are seasonal weather conditions, and milking management and machine factors (Table 4). Machine factors affecting hyperkeratosis (Table 3) are principally:

- Inappropriate vacuum levels,
- High levels of teat compression during liner closure and
- Prolonged machine-on time.

Machine-on time is most influenced by the presence and threshold settings levels of automatic cluster detachers (Shearn and Hillerton 1996; Rasmussen, 1993). Faulty pulsation is not indicated by hyperkeratosis.

Teat end hyperkeratosis may be exacerbated by disinfectants that cause chemical irritation to teat skin but it is questionable whether it may be improved by the use of a disinfectant with a high concentration of an effective emollient (Britten et al 2004).

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 (Neijenhuis et al 2001a).
Table 4. Major risk factors affecting teat end hyperkeratosis

<table>
<thead>
<tr>
<th>Risk factor</th>
<th>Reason for increased likelihood of teat end hyperkeratosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pointed teats</td>
<td>The load applied by the closing liner is on a smaller area of teat surface</td>
</tr>
<tr>
<td>Increasing age</td>
<td>The ‘wrinkle factor’ in all species</td>
</tr>
<tr>
<td>Higher production</td>
<td>Cups are on for longer</td>
</tr>
<tr>
<td>Peak lactation</td>
<td>Cups are on for longer</td>
</tr>
<tr>
<td>Udder washing</td>
<td>Water and chemicals reduce skin moisture and elasticity</td>
</tr>
<tr>
<td>Cups on before let down</td>
<td>Longer period of milk flow below one litre per minute</td>
</tr>
<tr>
<td>Low thresholds for Automatic Cluster Removers (ACRs)</td>
<td>Longer period of milk flow below one litre per minute</td>
</tr>
<tr>
<td>Over milking</td>
<td>Longer period of milk flow below one litre per minute</td>
</tr>
<tr>
<td>High vacuum</td>
<td>Greater stress on teat tissues – more stretched in the open liner and squeezed in the closer liner</td>
</tr>
<tr>
<td>Stiff liner mouthpiece</td>
<td>The lip acts like a tourniquet which slows or restricts outflow of blood from the teat wall when the liner is collapsed</td>
</tr>
<tr>
<td>Liners mounted at high tension</td>
<td>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)</td>
</tr>
</tbody>
</table>

For routine field evaluation (in contrast to more detailed research observations), teat ends are often scored as shown in Table 5.

Table 5. A scoring system for teat end hyperkeratosis (from Mein et al 2001)

<table>
<thead>
<tr>
<th>Score</th>
<th>Description</th>
<th>Illustration</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>No ring</td>
<td><img src="image1.png" alt="Illustration" /></td>
</tr>
<tr>
<td></td>
<td>The teat end is smooth with a small, even orifice.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>This is a typical status for many teats soon after the start of lactation.</td>
<td></td>
</tr>
<tr>
<td>S</td>
<td>Smooth or Slightly rough ring</td>
<td><img src="image2.png" alt="Illustration" /></td>
</tr>
<tr>
<td></td>
<td>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.</td>
<td></td>
</tr>
<tr>
<td>R</td>
<td>Rough ring</td>
<td><img src="image3.png" alt="Illustration" /></td>
</tr>
<tr>
<td></td>
<td>A raised, roughened ring with isolated fronds or mounds of old keratin extending 1-3 mm from the orifice.</td>
<td></td>
</tr>
<tr>
<td>V</td>
<td>Very rough ring</td>
<td><img src="image4.png" alt="Illustration" /></td>
</tr>
<tr>
<td></td>
<td>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.</td>
<td></td>
</tr>
</tbody>
</table>
C. 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, pus-forming or necrotising 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.

Typical lesions associated with these conditions are summarised in Table 6 and the more commonly occurring conditions are described further in the text below. For more information on all conditions, see the relevant SmartSAMM Advisor Note.

See Guideline 9 for images of teat conditions.

<table>
<thead>
<tr>
<th>Organism type</th>
<th>Condition or agent</th>
<th>More information</th>
<th>Typical lesion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Virus</td>
<td>Pseudocowpox</td>
<td>‘Pseudocowpox’ Advisor Note</td>
<td>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.</td>
</tr>
<tr>
<td></td>
<td>Bovine herpes mamillitis</td>
<td>‘Bovine herpes mamillitis’ Advisor Note</td>
<td>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.</td>
</tr>
<tr>
<td></td>
<td>Teat warts/papilloma</td>
<td>‘Teat wart’ Advisor Note</td>
<td>Appearance varies with strain of virus from ‘rice grain’ in appearance, to fronds.</td>
</tr>
<tr>
<td></td>
<td>Foot and Mouth Disease (exotic)</td>
<td>‘Other viral conditions’ Advisor Note</td>
<td>Occasionally, the virus causes vesicular lesions and erosions on teats (exotic) before they appear in the mouth or hoof.</td>
</tr>
<tr>
<td></td>
<td>Vesicular stomatitis (exotic)</td>
<td>‘Other viral conditions’ Advisor Note</td>
<td>Lesions similar to, and need to be differentiated from, Foot and Mouth Disease.</td>
</tr>
<tr>
<td>Bacteria</td>
<td>Staph. aureus, Strep. dysgalactiae A. pyogenes</td>
<td></td>
<td>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.</td>
</tr>
<tr>
<td></td>
<td>Blackspot or Fusiformis necrophorum</td>
<td>‘Blackspot’ Advisor Note</td>
<td>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.</td>
</tr>
<tr>
<td>Fungi</td>
<td>Ringworm or Trichophyton spp.</td>
<td></td>
<td>A characteristic grey-white encrustation. The infection may spread to milking staff.</td>
</tr>
</tbody>
</table>
1. Viral infections of teat skin

Viral infections vary in their severity, infectivity and frequency of occurrence. Generally, they are rare in dairy industries 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.

Early generation iodine disinfectants, with low pH, have a virucidal activity. Post-milking disinfectants and emollients reduce the incidence of the sores, rough skin, and cracks necessary for viral penetration and development. Some non-iodine teat disinfectants are less active against viruses.

Commonly, multi-use ointment containers are a significant source of new infections from poor hygiene. When treating any lesions with ointments, it is important to use only single-use containers and clean gloves and applicators where necessary.

Some exotic diseases can also cause lesions on teats (Hillerton et al 2001; Parkinson et al 2010). Some of the more common conditions are summarised below, but differential diagnosis for more unusual teat lesions should include:

- Foot and Mouth Disease (FMD),
- Vesicular stomatitis (VS),
- Bovine herpes mamillitis (BHM),
- Ringworm.

**Pseudocowpox**

Pseudocowpox, a paravaccinia virus, causes acute infection in young cows after calving or cows introduced to a herd that has the virus infection. The spread of the infection can be relatively slow. Immunity is short-lived, lasting four to six months, and infections can be a chronic problem in some herds. As a consequence, cows in affected herds are likely to suffer repeat infections.

Early lesions are painful and affected animals resent being milked. The characteristic ring or ‘horseshoe’ shaped scab (Table 6) usually heals without scarring in 3-6 weeks. Milkers may develop localized lesions, usually on their hands, i.e. ‘milkers’ nodules’. No specific treatment exists.

Spread of infection can be minimised by milking infected cattle last, and by wearing gloves. Successful treatment depends on consistent complete coverage of teats with a licensed and effective disinfectant.

**Teat warts or papilloma**

Six separate papilloma viruses cause teat warts including: the ‘rice grain’ flat white warts (strain BVP-5); frond-like papillomas that protrude in a ragged fringe of up to one centimetre in length (strain BVP-6); and fibropapillomas that protrude from the teat surface (strain BVP-1).

Young animals are very susceptible to papilloma viruses, and usually develop immunity soon after they enter the milking herd. In older cattle, papilloma are usually confined to the udder and teat. Spread is between animals via teatcup liners and milkers’ hands.

There is a wealth of anecdotal evidence that certain areas are more prone to warts, usually areas close to low lying river plains and forests.
Warts can interfere with the function of the liners and can, in some cases, block the teat canal. If they become damaged, they may be colonised by \textit{Staph. aureus}, \textit{Arcanobacterium pyogenes} or \textit{Strep. dysgalactiae}.

Most warts are self-limiting and disappear within 5-6 months. The frond type can be physically removed. If there is a major problem in a herd, an autogenous vaccine can be made from wart tissue from cows in the herd. Type-specificity is high, so vaccines must include all serotypes and tissue types responsible for the outbreak. The response of the low, flat warts to vaccination is relatively poor. Teat dipping with a salicylic acid formulation is often used for heifers.

\textbf{2. Bacterial infections of teat skin}

Bacteria cause primary lesions or colonise existing lesions caused by machine-induced damage, environmental factors or viral infections. \textit{Staph. aureus}, \textit{Strep. dysgalactiae} and \textit{Arcanobacterium pyogenes} are ubiquitous on the skin of dairy cows. They are a major source of new intramammary infections and clinical mastitis, in lactating and non-lactating cows. It was shown clearly some 30 years ago that chapped teats were highly likely to be infected with \textit{Staph. aureus} or \textit{Strep. dysgalactiae}, and that such infections were closely associated with high new infection rates and frequent cases of clinical mastitis (Dodd and Neave 1970; Kingwill \textit{et al} 1970). Even small teat lesions are significantly associated with sub-clinical mastitis and the risk of mastitis increases for lesions that are closer to the teat canal (Agger and Willeberg 1986).

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.

\textit{Blackspot}

Blackspot is the manifestation of a secondary infection of a teat end lesion by the anaerobe \textit{Fusiformis necrophorum}. The primary lesion is colonised following poor hygiene. The resulting scab is pigmented black by the bacteria. The teat orifice may become blocked, leading to incomplete and very slow milking.

If more than 2–3\% of teats are affected, hygiene should be improved and milking machine function should be thoroughly checked because blackspot is often associated with short teatcup liners, failure of pulsation, excessive vacuum or over milking.

Management of Blackspot in a herd involves:

- treating the lesions with iodine (or hydrogen peroxide);
- using teat disinfection to minimise bacterial infection of lesions; and
- checking the milking machine function.
3. **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.

Few treatments are recognised for ringworm. Generally the disease is self-limiting after a few months. In some countries, vaccines are available for calves, which can reduce the number of animals affected in the herd.
**D. Systematic evaluation of teat condition in commercial herds**

1. **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. In 2001, the Teat Club International recommended that teat condition be scored using a pass/fail criterion on all teats of all cows in the herd, if time and herd size allowed, or randomly selecting at least 80 cows, or 20% of the herd (whichever was the largest number of cows; Reinemann *et al* 2001).

   In NZ, there are two approaches supported. Assessment of 50 cows, randomly selected throughout the herd, is recommended for farmers and milk quality advisors needing to quantify a potential problem, and know when to seek further advice.

   Assessment of a larger sample of cows is recommended for vets and professional advisors when investigating system faults and potential causes of teat damage.

   **SmartSAMM recommendations**

   - Assess all teats on at least 100 cows, selected randomly throughout the herd.
   - Cows need to be selected randomly throughout a milking and across mobs to ensure a representative sample.
   - Record results for all 4 teats of each cows, if practicable.

   **Evaluation Method A - Quarter-level recording**

   1. Examine all teats of the selected cows.
   2. Score the exceptions (non-normal) at a cow and quarter level.
   3. Record the cow and quarter details for each issue.

   **Benefits:**

   - Measures prevalence at quarter level.
   - Provides a comprehensive list of cows and quarters that can be re-examined once an intervention has been applied.
   - Use this technique for research purposes, for quantifying the specific impact of an intervention, or resolving teat end damage on specific cows.

   **Disadvantages:**

   - More time consuming.
   - Often requires more labour units to perform, to minimise disruption.
   - Quarters within cows are not truly independent. That is, where one quarter is abnormal, another quarter within that same cow is more likely to be abnormal than a quarter drawn at random from another cow in the population. This means that more quarters need to be recorded to provide confidence about the result.

   **Evaluation Method B - Cow-level recording**

   1. Examine all teats of selected cows; only score the worst teat for each animal.
   2. Assign this score to the cow.
   3. Record the score, but not necessarily the cow and quarter details.
4. Be aware of patterns of damage in certain locations of the udder to help diagnose the problem.

**Benefits:**
- Provides a simplified process where size, speed or cost is an issue.

**Disadvantages:**
- Less information available to help diagnose subtle problems associated with specific quarters in cows being affected.
- Unable to recheck the same cows later in time as cow details not recorded.
- Does not provide a true estimate of prevalence, but rather is the prevalence of cows with at least one quarter scored as positive for a particular characteristic.
- Will result in a higher estimate of prevalence than scoring at quarter level.

**Note on interpreting prevalence for cow and quarter-level recording**

When only the worst teat in the cow is scored, the prevalence will be higher than if each quarter was assessed (Figure 1). This is because cow-level assessments are a ‘parallel’ interpretation of the 4 teats. Higher thresholds are required at which the milking processes can be considered to contribute to a mastitis problem, if cow-level recording is used, compared to quarter-level recording.

Figure 1 compares prevalence of teat end scores determined using cow-level and quarter-level recording systems. The data relates to assessment of 9,169 quarters across 2,292 cows in 4 herds in early lactation (Adamson, McDougall and Roberts, unpublished results).

Prevalence of rough (R) or very rough (VR) teat ends, calculated at a quarter-level (i.e. number of teats scored as R (or VR)/total number of quarters assessed), was 4.7% and 1.3% of quarters, for R and VR teat ends, respectively. Prevalence calculated at a cow-level (i.e. number of cows with the worst gland within the cow being R (or VR)/total number of cows examined), was 10.3% and 3.5% of cows with one or more R or VR teat ends respectively.

**Figure 1 Variation in prevalence of rough (R) and very rough (VR) teat end scores when calculated at quarter or cow level.**
2. **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 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 work safety.
- To ensure confidence in the data, score a representative sample of cows from all age groups or management groups. Where multiple sub-herds are run, examination of cows should occur in all sub-herds. Additionally, sampling should occur across the milking, not just at the beginning or end. One way of achieving this is to calculate the number of cows that need to be sampled (see below) then divide this into the number of cows in the group, and the result of this calculation is the gap between cows to be sampled. For instance if it is a 400 cow herd and 50 cows are to sampled then every 8th cow (400/50) should be examined.
- 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 (or lawyers!). Before and after photos of specific cows can also be used for more in depth examination of certain conditions (Reinemann 2007).
3. Interpreting the results

Once a particular teat condition has been evaluated, the prevalence, at a cow or quarter-level can be calculated.

Thresholds for intervention (or “Triggers for Action”) have been developed by Teat Club International, based on field experience across a number of different countries and environments (Reinemann et al 2001). These thresholds vary, depending on:

- The criteria being evaluated.
- Whether the evaluation is at the cow or quarter-level. Generally the cow prevalence of teat conditions is 2.5 times that for quarters. So the trigger for action at a cow-level tends to be 2.5 times that for quarter-level data.
- Herd-specific circumstances e.g. season, that may necessitate changing thresholds.

Triggers for Action

Further investigations of milking machine, management, environmental and infectious factors may be required if the triggers listed in Table 7 are exceeded.

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. Some herds that do have teat abnormalities may have values slightly below the threshold because:

- the sample of teats observed was not representative of the herd; or
- the estimate generated by the sample is within the lower limit of the 95% confidence interval for the threshold value (see Table 7).

If in doubt, it is 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.

The primary focus of observation is on teats (rather than cows), because this is the easiest way to make an initial assessment of whether or not a problem exists within a herd. Therefore, the first analysis is the proportion of teats affected with a particular condition.

Clearly this initial assessment may require some qualification. For example, a high proportion of cows may have the same teat affected. Alternatively, only a few cows may contribute most of the ‘problem’ teats if they each have 3-4 teats affected. These types of patterns can be very helpful indicators of a milking machine problem or a cow problem.
### Table 7 Trigger levels for action for different teat abnormalities (from Reinemann et al 2001 and Reinemann 2007).

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Description</th>
<th>Quarter-level</th>
<th>Cow-level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teat Colour</td>
<td>Red/Blue&lt;br&gt;Light coloured teats are visibly reddened (congested) or tinged with blue (cyanotic).</td>
<td>8%</td>
<td>20%</td>
</tr>
<tr>
<td>Swelling</td>
<td>‘Ringing’ at teat base&lt;br&gt;Marked swelling or palpable rings at or near the top of the teat.</td>
<td>8%</td>
<td>20%</td>
</tr>
<tr>
<td>Firmness</td>
<td>Hard or Wedged&lt;br&gt;Teat ends are classified as firm, hard, swollen, or noticeably wedged.</td>
<td>8%</td>
<td>20%</td>
</tr>
<tr>
<td>Openess</td>
<td>Open&lt;br&gt;Teat ends classed as open after milking.</td>
<td>8%</td>
<td>20%</td>
</tr>
<tr>
<td>Teat end</td>
<td>Hyperkeratosis&lt;br&gt;Teats are scored R or V</td>
<td>8%</td>
<td>20%</td>
</tr>
<tr>
<td></td>
<td>Teats are scored as V</td>
<td>4%</td>
<td>10%</td>
</tr>
<tr>
<td>Vascular damage</td>
<td>Haemorrhages&lt;br&gt;Light-coloured teats have Moderate or Severe petechiation</td>
<td>4%</td>
<td>10%</td>
</tr>
<tr>
<td>Teat skin</td>
<td>Dryness, Roughness&lt;br&gt;Teat skin scored as rough, dry and scaly.</td>
<td>4%</td>
<td>10%</td>
</tr>
<tr>
<td>Lesions</td>
<td>Chaps, cracks&lt;br&gt;Teats have open lesions, cracks or chaps.</td>
<td>2%</td>
<td>5%</td>
</tr>
</tbody>
</table>

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 low flow below 1 litre/minute and/or over milking.

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.

---

**If the assessment has been conducted at a quarter level:**

Table 8 lists the number of quarters with a teat abnormality at which it is likely that the prevalence of teat lesions is 8%, 4% or 2%. (Note: the number of quarters has been adjusted to account for the ‘clustering’ effect i.e. that quarters within a cow are not independent of each other. A variance inflation factor of 1.5 has been applied (S. McDougall pers. comm.).

So if 4 or more teat with abnormalities are found, following examination of 200 teats (all quarters of 50 cows), it is 95% likely that the prevalence is not different from 8%. But even if no abnormalities are found, after examining 200 quarters, the possibility that prevalence of teat abnormalities is 4% cannot be ruled out.
Table 8. The lower 95% confidence interval of number of quarters (or cows) that are significant (i.e. not different from the trigger level) when prevalence of the abnormality is 8%, 4% or 2% (quarters) or 20%, 10%, 5% (cows), based on a binomial distribution. If the number of abnormalities is greater than the number listed for that sample size, then the herd prevalence of that condition is not different from the trigger level, with 95% confidence.

<table>
<thead>
<tr>
<th>No. quarters (cows) examined</th>
<th>Quarter prevalence</th>
<th></th>
<th>Cow prevalence</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>8%</td>
<td>4%</td>
<td>2%</td>
</tr>
<tr>
<td>100 (25)</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>150 (38)</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>200 (50)</td>
<td>4</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>250 (63)</td>
<td>7</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>300 (75)</td>
<td>10</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>350 (88)</td>
<td>13</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>400 (100)</td>
<td>15</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>450 (113)</td>
<td>19</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>500 (125)</td>
<td>22</td>
<td>7</td>
<td>0</td>
</tr>
<tr>
<td>550 (138)</td>
<td>25</td>
<td>8</td>
<td>0</td>
</tr>
<tr>
<td>600 (150)</td>
<td>28</td>
<td>9</td>
<td>1</td>
</tr>
<tr>
<td>650 (163)</td>
<td>31</td>
<td>11</td>
<td>2</td>
</tr>
</tbody>
</table>

More quarters should be examined to rule out a prevalence of 4%. Conversely if 200 teats are examined and less than 4 teat abnormalities are found, it is 95% likely that the prevalence of teat abnormalities is less than 8% (but a prevalence of 4% or 2% cannot be ruled out).

If the assessment has been conducted at a cow level:

Table 8 lists the number of cows with teat abnormalities at which it is likely that the prevalence of a cow having at least one teat with an abnormality is 20%, 10% or 5%. Figure 2 shows the relationship between these different levels of prevalence (cow-level).

If 6 or more cows are found to have at least 1 abnormal quarter, following examination of 50 cows, it is 95% likely that the prevalence is not different from 20%. But even if no abnormalities are found after examining 50 cows, the possibility that the prevalence of teat abnormalities is 5% cannot be ruled out. More quarters should be examined to rule out a prevalence of 5%. Conversely if 100 cows were examined and no teat abnormalities were found, it is 95% likely that the prevalence of cows with teat abnormalities is less than 5%.
9.2 Minimise the build-up of mud on teats.
Reduce teat condition and hygiene problems caused by mud by maintaining clean, dry trough areas, farm tracks, laneways, feed pads and stand-off areas, and entrances and exits to the farm dairy.
If wet and muddy conditions cannot be avoided for lactating cows, and the rate of new clinical cases starts to increase, teats will need to be washed and dried before each milking.

9.3 Minimise water on cows’ udders.

9.4 Check teat spray mix, particularly emollient concentrations.

9.5 Check important milking machine factors.
Call in a NZMPTA-certified milking machine tester if concerned that the operation of the milking machine is contributing to teat damage.

Technote 26 discusses ways to fix areas that make udders muddy.

Technote 5.3 discusses udder cleanliness and pre-milking preparation.

Technote 7.5 discusses addition of emollients to teat sprays.

Technote 24 discusses servicing of the teat spray equipment.

Technote 6.1 describes how to monitor and maintain milking machine function.

Technote 25 describes tests that can be carried out by certified milking machine testers.

Figure 2. Comparison of the cow trigger levels for different number of cows examined.
9.6

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 teatcup ‘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 varieties that use a base such as sorbylene 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.

9.7

Seek advice from your veterinarian if problems persist.

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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These SmartSAMM adapted resources are made available to NZ dairy farmers and advisors through a Memorandum of Understanding between...
Key papers

Teat Club International papers


Other papers


Hillerton JE, Ohnstad I, Baines JR, Leach KA. Changes in cow teat tissue created by two


Kingwill RG, Neave FK, Dodd FH, Griffin TK, Westgarth DR, Wilson, CD. The effect of a mastitis control system on levels of clinical and sub-clinical mastitis in two years. *Vet Record,* 1970; 87:94-100.


