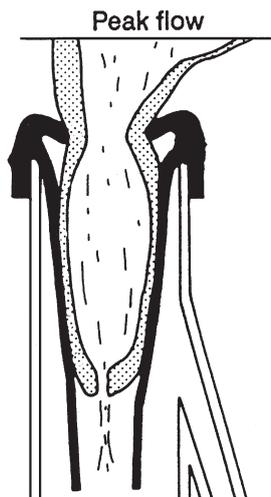
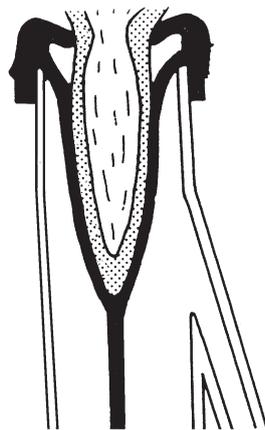




### Forces applied to teats at milking



Machine milking pulls the teat canal open with a vacuum



Pulsation provides a massaging action to keep the teat healthy

### What happens during machine milking

During the milk-flow phase of pulsation, the teat is drawn into the liner and stretched lengthwise and the teat barrel conforms to the internal diameter of the liner. Stretching of the teat walls pulls the teat canal open. Milk is sucked from the teat by vacuum in the open liner of the teat cup. The teat end is constantly exposed to the vacuum, and fluid accumulates in blood vessels and tissues in this region of the teat.

The pressure of milk in the teat keeps the liner in position. The liner can slip toward the end of milking when there is insufficient milk to swell the teat.

Closure of the liner massages the teat. At the onset of the 'massage' phase of each pulsation cycle, the collapsing liner places most of its compressive force on the teat end (the force placed on the teat end during this phase increases with the vacuum of the system) and little load is placed on the teat barrel. The massage phase reduces teat end congestion by distributing fluid, drawn into the teat end under vacuum, upwards throughout the teat tissue.

Each cluster has a small vent that admits air into the claw bowl during milking. This has several benefits as it:

- breaks the column of milk into smaller amounts and therefore helps maintain the claw vacuum close to the milk line vacuum (especially when milk is being lifted to an overhead milkline);
- reduces vacuum fluctuation in the cluster caused by the opening and closing of the liners; and
- helps promote smooth cup removal. When the vents are blocked, the cups stay on the cow for longer and operators tend to break the vacuum at the cup.

Optimal milking machine operation for mastitis control aims to:

- stop bacteria entering the teat canal during milking by minimising impacts caused by liner slip, blocked air vents, rough cup removal or vigorous machine stripping; and
- keep teat skin and teat canals healthy by ensuring correct vacuum, pulsation, liner action and milking techniques.

Field experience shows that mastitis problems are often resolved by fixing simple problems such as unsuspected high vacuum, pulsator or liner problems, or by clearing blocked air vents. Furthermore, teat condition usually is improved by more careful attention to the timing of teatcup application and removal.

A regular, detailed and comprehensive analysis of milking machine function is necessary to define and correct problems.

## 6.1 Use the daily, weekly and monthly guides to check machine function

Extensive field experience has shown the most common reason for milking machine problems is inadequate routine maintenance of mechanical components and rubberware. A series of regular, systematic checks ensure preventive maintenance and enable basic trouble-shooting (Mein 1997).

### Recommended daily, weekly and monthly checks of milking machine function

Daily checks <sup>1</sup>	Weekly checks <sup>1</sup>	Monthly checks <sup>2</sup>
Check air admission holes (vents).	Check for twisted liners.	Check regulator functions.
Read the vacuum gauge and record results.	Check liner condition.	Measure completeness of milking and milking times.
Listen to the pulsators.	Check filters on pulsators or on filtered air supply lines.	Count cup squawks and slips requiring correction by milker.
Watch milk entering the receiver can to ensure an even flow.		
Check teats as cups come off.		
Note cow behaviour.		

1. This task should be assigned to one of the regular milking staff.

2. This task should be the responsibility of the herd manager.

### Milking-time tests

The daily, weekly and monthly checks of milking machine function include five milking-time tests that monitor teat condition, cow behaviour, average milking time, completeness of milking, and the frequency of slipping or falling teatcups. A detailed description of each milking time test is given below.

#### Machine function and teat condition

Ideally, teats should be as soft and supple just after milking as before milking. Teat tissue undergoes both short-term and long-term changes in response to the forces experienced during milking. Generally, changes in the teats due to machine milking are most obvious at the teat end.

Teats that are slightly swollen or hard (due to congestion or oedema) or slightly blue or purple in colour (cyanotic) after milking result from machine-induced circulatory impairment. Usually, teats are thicker (with fluid) after milking with wide-bore liners, or at high vacuum level (Hamann et al 1994). Cyanosis or oedema around the teat apex or lower barrel often indicates some type of pulsation failure such as insufficient collapse phase of pulsation, short teatcup liners or liners with insufficient tension. Cyanosis or oedema around the upper barrel of the teat may be due to liners with hard mouthpiece lips or high mouthpiece vacuum (Hillerton et al 1998, Ramussen 1997) or to over milking or slow milking, often exacerbated by attaching teatcups before milk ejection has occurred.

#### Confidence – High

The most common reason for milking machine problems is inadequate routine maintenance of mechanical components and rubberware.

#### Research priority – High

Further development of practical milking time tests and guidelines would be helpful. Training for veterinarians and technicians is essential. Development and evaluation of automated warning systems for faults and service requirements are recommended.

Technote 9.1 describes how to assess teat skin and teat ends.

Technote 9.1 gives interim guides for the prevalence of different teat scores in normal and problem herds.

The act of milking aggravates all types of teat lesions. Machine milking is a main cause of hyperkeratosis (teat canal or orifice), petechial haemorrhages (tiny blood-blisters) near the teat end, and may exacerbate teat chapping. A high incidence of teat orifice abnormalities, such as hyperkeratosis or radial cracking ('rings' or callouses), may result from excessive vacuum, over milking, hard liners or liners mounted at unnecessarily high tension. Petechial haemorrhages around the teat end, and possibly 'black spot' at the external teat orifice, are useful indicators of some type of pulsation failure such as short teatcup liners or insufficient collapse phase of pulsation.

Oedema and small haemorrhages at the teat end heal quickly, but can be important early warning signs of a machine problem and an increasing mastitis risk. Regular checks of vacuum levels, pulsators and liner suitability will help avoid teat damage. Over milking for a period of five minutes on four consecutive milkings is sufficient to cause tissue damage (Hamann et al 1994). Over milking, excessive vacuum and failure of pulsation greatly increase the likelihood of tissue changes in the teat.

#### Machine function and cow behaviour

Signs of discomfort or nervousness when cups are put on or taken off should also alert milking staff to the possibility of problems with milking machine function (Hillerton et al 1998).

Frequency of flinching, stepping or kicking (the 'FSK' response) is an indicator of comfort/discomfort while the milking unit is on the cow. For on-farm observations, however, variations in the frequency and expression of flinching are too subtle to be a reliable indicator when observing more than one cow at a time.

Guidelines for observing cow behaviour:

- One observer can watch the rear legs of up to four cows at any one time, provided that he or she stands out of the way but close to the stalls.
- A step means lifting a hoof clear of the floor. Because this involves a significant and deliberate shift in weight for the cow, it is easy to observe and record.
- A kick means that a hoof is aimed at a person or at the milking cluster (including any deliberate attempts by the cow to remove the cluster by pressing on it with her hoof).
- Observations should be recorded together with a time stamp so that data can be grouped and analysed as kicks/steps (the 'KiSt response') during specified events such as:
  - When cows are in the stall waiting to be milked. (Discomfort at this point may suggest environmental factors such as flies or poor design of the stalls.)
  - When operators are preparing the udder, attaching or re-attaching units, or at post-milking disinfection. (Discomfort may indicate a problem of interactions between the operator and a cow, or the milking machine and cow.)
  - During the first two minutes of milking and the last two minutes of milking. (Discomfort during these periods suggest machine effects).

These data can be analysed as the proportion of cows exhibiting 0 or 1, 2-4, 5-10, or >10 'KiSt' responses at different periods of milking.

A video camera can be used in lieu of direct observations. If a video camera can be set up to record 1-2 hours of milking, the video can provide an effective means of demonstrating and analysing behavioural responses with minimal interruption to the normal milking routine.

Use of a chart enables objective assessment of cow behaviour at different stages during milking. See Technote 13 for example chart.

The sensitivity of teats to being touched can be assessed by manual palpation just after milking (Hillerton et al 1998). However, results in commercial herds will depend to a large extent on whether cows are accustomed to being touched after milking.

#### Milking time guide

Field studies in France (Billon 1993) and the United States (Stewart et al 1993, Thomas et al 1993) all show remarkably consistent regressions for the relationship between the average milking time and the average milk yield per cow per milking.

Research conducted by the Department of Primary Industries, Victoria showed clearly that taking the cups off at a pre-determined Maximum Milk-Out Time (MMOT) saves time without affecting milk production, quality, mastitis or milk cell counts.

A herd's MMOT depends on the average milk production per cow per milking. For example, 80% of cows in a typical Australian herd in which cows are producing an average of 10 L at a single milking will be milked in 6.3 min. If MMOT was applied at this suggested target level of 80%, then the slowest 20% of cows in that herd would have their milkings truncated by pulling clusters off after 6.3 min.

Revised Technote 5 (2010) describes the effects of under and over milking and how to achieve shorter milking times in herds.

### Recommended reading

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

Mein et al 2010.

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

### Completeness of milking

Qualitative and semi-quantitative guidelines for defining and assessing completeness of milk-out of individual quarters are given in the table below (from Mein et al 2010). The qualitative guidelines are a practical alternative for use in herds where hand-stripping would cause unacceptable disruption to the operators' milking routine – or unacceptable risk from kicking by cows that are unaccustomed to having their teats handled after milking. The semi-quantitative assessment provides guidelines for selective hand-stripping, in combination with the qualitative assessment, to improve the reliability of diagnosis. Guidelines for assessment of udder strip yields by machine stripping are also included in the table. Although machine stripping may provide a more reliable and repeatable measurement method, its use is essentially limited to milking systems where permanent milk meters are installed.

Guidelines for assessing and recording the completeness of milk-out

Record milk-out as:	Qualitative assessment	Semi-quantitative (hand-stripping of individual quarter)	Machine-stripping (based on whole udder)
G (Good)	Quarter is visibly wrinkled	4 or fewer strips (equating to < 100 mL per quarter)	Less than 500 mL per udder
P (Poor)	Quarter appears slightly plump, possibly indicating unharvested milk	5 or more easy strips (equating to more than about 100 mL per quarter)	More than 500 mL per udder
U (Uneven)	One particular quarter appears plumper and less wrinkled, relative to the other quarters		One particular quarter appears plumper and less wrinkled, relative to other the quarters

Further details are given in the paper: "How completely should we aim to empty cows' udders at milking time?" (Mein et al 2010).

Consistent differences between strip yields in rear versus front quarters, or between quarters on the right side versus left side, usually indicate a problem of poor cluster positioning and/or cluster weight balance.

Technote 5.8 discusses the effect of undermilking on mastitis and yields.

The most common causes of incomplete milking are:

- poor type or condition of the liner;
- clusters that do not hang evenly on the udder because the connecting hoses are too long, too short, twisted, or poorly aligned in relation to the cow;
- clusters that are too light in relation to the bore of liner used and/or the system vacuum;
- high milking vacuum levels; and
- a mismatch between the claw inlet and the short milk tube causing partial closure of the short milk tube where this tube joins the claw.

### Frequency of slipping or falling teatcups

A comprehensive summary (O'Shea 1987) of research herd data suggested that generalised vacuum fluctuations per se did not increase new infection rates but new infections were greatly increased by liner slips. Curiously, the effect of liner slips on mastitis incidence has never been established in large-scale field trials. However, the economic importance of liner slips can be inferred from field studies with deflector shields fitted into the liner or with one-way valves fitted between the short milk tube and claw. Field experiments with deflector shields in Britain and Australia (Griffin et al 1980) and in Norway (Binde et al 1989) indicated an overall reduction in new infection rate of about 10-15%. It is likely that these devices prevented all or most of the effects of liner slip on new infection rates.

More recently, the effect of a 'high' versus a 'low' slip liner on new infection rate was assessed in the United States using a 160-cow research herd under conditions of natural exposure and post-milking teat disinfection (Baxter et al 1992). Slips were recorded whenever a vacuum drop of 10 kPa or more occurred within a time of 0.25 seconds or less. The 'high slip' liner averaged 7.6 major slips per cow-milking, compared with 3.1 for the 'low slip' liner. New infection rates were 0.49 per 100 cow-days for high slip compared with 0.27 for the low slip liner. Interestingly, this works out to about one new infection per 2,500 liner slips for both the high and low slip liners. Not surprisingly, the new infection rate was higher in cows with one or more quarters already infected (1,500-1,850 slips per new infection) compared with previously uninfected cows (more than 6,000 slips per new infection).

Such results indicate that slipping teatcup liners might cause 10-15% of the new mastitis infections on an 'average' farm. The effect could be well above this average on some farms depending on individual herd factors such as the prevalence of subclinical infections and quality of milking management, and machine factors such as type of liner, bore of short milk tubes and claw volume.

The incidence of slipping or falling teatcups can be assessed by careful observation. As a guideline, Mein and Reid (1996) suggested that slips or falls requiring correction by the milker(s) should be less than 10, and preferably less than 5, per 100 cow-milkings. Slipping or falling early in milking often results from low vacuum level (especially in combination with excellent udder preparation), or with blocked air vents or restrictions in the short milk tube. Poor cluster alignment, poor liner condition or uneven weight distribution in the cluster are common causes of slipping and falling late in milking.

### **Documentation of monthly checks of machine function**

Results of the monthly checks should be recorded so trends can be assessed regularly. A standard place, such as an exercise book, wall calendar, pocket book or electronic file may be used.

The monthly checks will help detect subtle changes due to wear and age in rubberware and equipment. For example:

- A monthly record of vacuum with one, or two, milking units open provides a simple method of testing for possible deterioration in the reserve vacuum pump capacity (due to pump wear, air leaks, or regulator performance).
- The required frequency of changing teatcup liners on farms can be assessed from a monthly record of the average amount of milk hand-stripped from a representative group of cows.

## 6.2 Call a milking machine technician if you observe any abnormalities in the dairy shed during your daily, weekly or monthly checks

Technote 25 describes regular testing and servicing of milking machines by qualified technicians.

### Confidence – High

Extensive field experience has shown that old liners reduce the speed and completeness of milking, and reduce milk quality.

### Research priority – High

Farmers and advisers need more objective criteria to determine the optimum time to replace liners.

See the [Liners FAQ sheet \(2003\)](#) for the structure and terms used to characterise teatcup liners and tips on changing old liners.

Most manufacturers recommend that rubber liners are used for 2,000-2,500 cow milkings and then changed.

## 6.3 Change liners at regular intervals

Teatcup liners are made of natural, synthetic (usually nitrile) or silicone rubber. They are shaped to:

- provide an airtight seal at both ends of the shell;
- provide a mouthpiece and barrel of a size that will fit on a range of teat shapes and sizes;
- minimise liner slips and cluster fall-off;
- allow for quick and complete milk out, while minimising teat congestion, discomfort and injury; and
- clean easily.

Liners are designed to flex and squeeze the teat during each pulsation. When fitted into a correctly matched teatcup, the liner should be stretched 5-15% more than its original length. Some liners have two or more 'tension notches' at their base. This enables them to fit a number of teatcups of slightly different lengths, and also allow them to be 'pulled up' onto the next notch to increase tension after some age-related stretching has occurred. Over-stretched liners may provide good milking characteristics but are more likely to cause teat damage.

As soon as they start working the liners gradually lose tension, absorb fat, and hold bacteria. Liners deteriorate under tension, and when exposed to sun, heat, chemicals and ozone (e.g. near motors). The rate that they deteriorate depends on the materials from which they are made, their storage, cleaning, and use. As an extreme example, some liners have passed their 'use-by-date' when they are put on the first cow due to poor storage. Perished liners reduce the speed and completeness of milking, increase teat end damage, or increase the spread of mastitis bacteria.

The Countdown Downunder Farm Guidelines for Mastitis Control show farmers how to calculate the life of rubber liners in their herd.

The recommended life of silicone liners is 5,000 cow-milkings or five months – whichever comes first. Theoretically they have a longer life than rubber liners as silicone doesn't absorb fat. However, in practice they are more susceptible to tearing and puncturing than rubber liners and are likely to split if cows step on them, as well as being 3-4 times more expensive.

The recommended interval for liner replacement is often shorter than people expect! Daily, weekly and monthly checks of milking times, milking completeness, teat end condition, and cup squawks and slippage will help alert to problems.

Frequently, independent professional advisers are asked to provide their farmer clients with recommendations for changing to a 'better' liner. Although there are many liners (often with very subtle differences), there is no comprehensive and readily available table for matching liners with shells.

## Choose liners that are compatible with shells, claw inlets, jettors and teats

(adapted from 'Happy Cow' publication, Fox, Eden & Associates, Hamilton, NZ, 'Learning about Liners', 2009).

In the absence of a comprehensive independent table for matching liners with other components of the cluster, or with the average size and shape of teats in a given herd, the initial search for a compatible liner can be simplified by considering the following aspects

"If you notice a difference when you renew liners, then the old ones were on too long." – Graeme Mein

Preferably, choose liners that are part of a manufacturer's chart of recommended matching combinations.

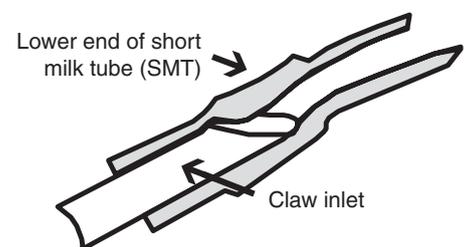
This strategy minimises potential compatibility problems and warranty issues.

### Ensure that liners fit the shell

- Ensure that liners do not leak when placed in the shell, that they cannot be twisted easily, and that the liner barrel is stretched by between 5% and about 15% of its original length when mounted in the shell.
- Is the liner mouthpiece distorted when it is mounted in the shell? Check by ensuring that the size and shape of the mouthpiece lip does not change substantially as the liner is mounted into the shell.
- Does the connection point at the bottom of the shell hold firmly, without air leaks or easy twisting of the liner in the shell? Additionally, hold the liner up to the light and look through it to ensure that the shell at the connection point does not noticeably constrict the internal diameter of the short milk tube.
- Does the internal diameter of the shell allow room for the liner to collapse beneath the teat? Check this by removing one or more liners from their shells and looking for signs of rubbing and wear along the outer surfaces of the liner barrel.

### Ensure that liners fit the claw nipples

- Check the internal diameter of the short milk tube (SMT) against the external diameter of the claw inlet. As a rough guide, liners are compatible with claw nipples if the bore of the SMT is 2-3 mm narrower than the external diameter of the nipple.
- Although the SMT will stretch somewhat, the more it has to stretch, the more prone the rubber is to 'stress cracking' and to split if a cow kicks or steps on the cluster. Furthermore, an overstretched SMT may restrict the size of the milk pathway from the SMT into the claw as illustrated in the diagram.



Note: the milk flow path from the teatcup into the claw is partially restricted at the point where the flexible SMT is connected to the rigid claw inlet.

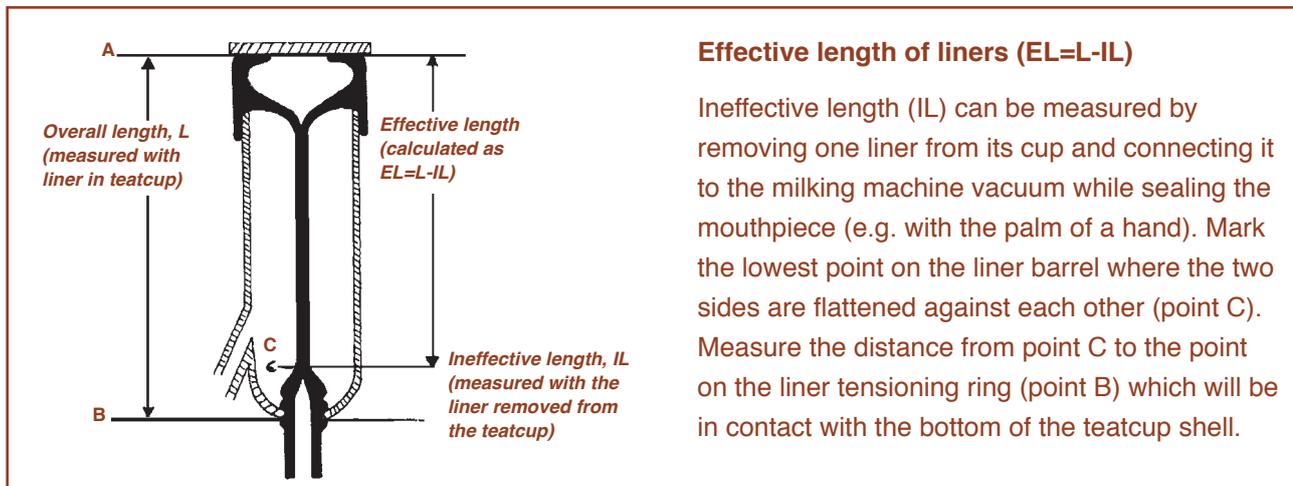
### Ensure that liners are compatible with the cleaning jettors

- Try before you buy. The liner needs to stay in or over the jettor during the wash cycle without substantial leaking of air so the 'cleaning in place' (CIP) system can operate effectively.
- Watch out for mouthpiece distortion if the liner mouthpiece does not match the cleaning jettor correctly.

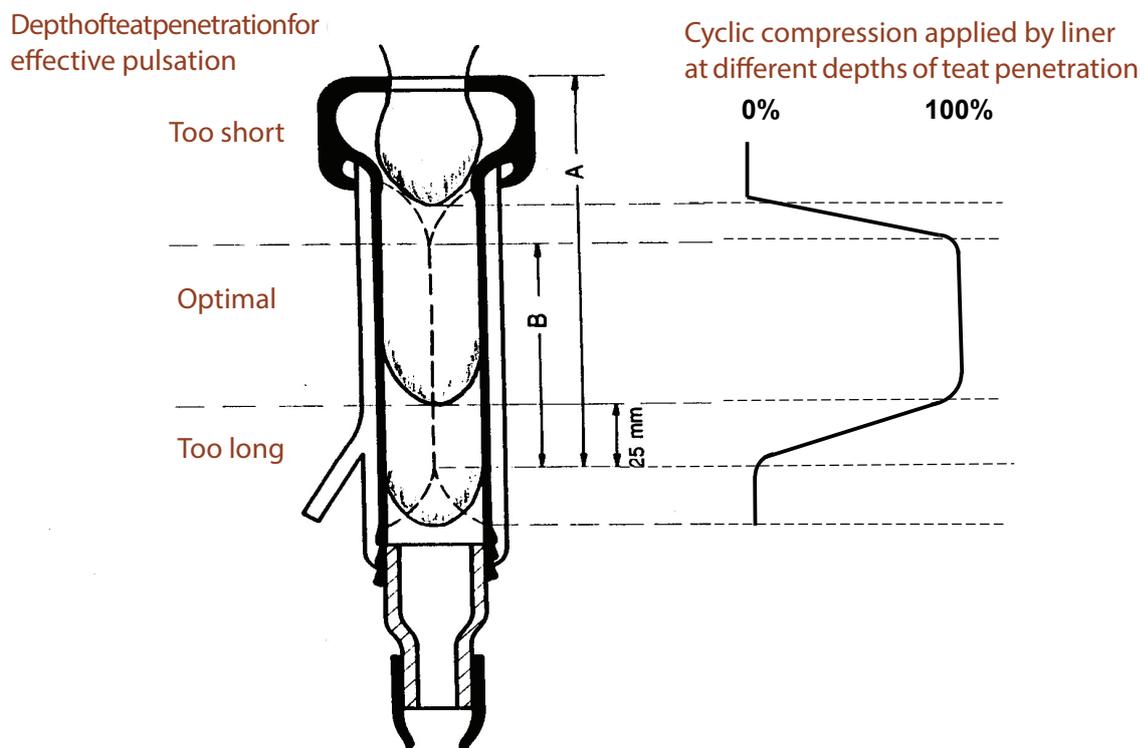
Ensure that liners match the average teat size for a given herd

This is the most important issue and it should be given top priority. As a general rule, it is wise to select liners to favour the younger cows rather than the older ones. It is self defeating to use, for example, large bore liners to get faster milking of old cows if that is going to cause teat stress or discomfort for the younger cows.

- Liner bore. As a general guide, medium bore liners (i.e. liners having a mid-barrel bore of 21.5-24.5 mm, measured 75mm below the mouthpiece lip) are suitable for average teat diameters of about 23.5 mm, which is typical for most Australasian herds (see FAQ, 'How can I tell if the liners need changing?').
- Effective length of a liner when mounted in its shell. Research in the 1970s showed that pulsation often failed on cows with long teats. Long teats were pulled so deeply into some liners that the teat-ends failed to get sufficient squeeze and the incidence of mastitis increased. The dairy industry responded to that discovery by producing liners with longer effective length to avoid this problem of pulsation failure. Nowadays, liner effective length has ceased to be an important practical issue because dairy breeding and selection programs have resulted in shorter teats for Australian and NZ cows. Although it is rare to see teats that are more than 75 mm long now, it is still useful to know how to calculate the effective length of a given liner (see figure and notes below). Assuming that 95% of teats are not more than 75mm in length, then a minimum effective length of about 135mm would be adequate for most liners and herds.



- Mouthpiece ineffective length. If the mouthpiece or lip cavity is too deep, very short teats often do not get adequate support from the liner barrel when it is open, or a proper squeeze from the closed liner. Such teats get insufficient relief from the milking vacuum and the cows do not like it! As a guide, this depth should not normally exceed 25 mm. The effects, on the degree of compression applied by the closed liner, are illustrated in the diagram below. These estimates of the relative 'Liner Compression' are based on unpublished measurements by Mein. Very short teats get little or no squeeze, especially if the mouthpiece cavity is too deep. Some long teats also get little or no squeeze because the liner cannot collapse beneath the teat-end.



- A = Effective length of the liner
- B = Effective collapse length
- $A - 25 \text{ mm}$  = max. teat penetration for effective pulsation
- $A - B$  = min. teat penetration for effective pulsation

#### Final selection of the 'right' liner

Final selection is always better done out in the farm dairy. Check the milking performance of liners on your 'short list' using the five key milking-time observations described in this Technote.

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