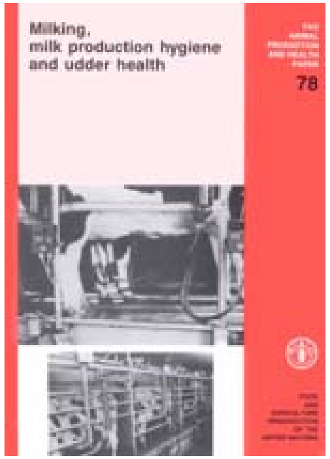
FAO ANIMAL PRODUCTION AND HEALTH PAPER 78



Milking, milk production hygiene and udder health

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FOREWORD

Milk production from cattle for human consumption dates back to prehistory. In former times the milk would be obtained from the family cow and usually consumed either as milk or a simple milk product within hours of milking. Today commercial milk production is a complex industry. A dairy herd can range in size from a few cows to several thousand. The milk may be stored on the farm for up to two days and transported long distances to urban centres for distribution as liquid milk or processed into cheese, butter, milk powder and many other

products. These milk and dairy products may not be consumed for weeks or months after the milk leaves the farm. Because milk and milk products are perishable foods high standards are required, for a successful, profitable dairy industry. The milk leaving the farm must be of good nutritional and bacteriological quality and be uncontaminated by soil and chemical pollutants. To a marked degree this quality depends on the methods of milking hygiene and milk storage on the farm.

This short monograph aims to provide a concise description of the methods that should be used on farms to produce high quality milk. It is impossible to deal in detail with all the equipment and methods currently used on farms for all commercial designs of equipment. These can vary from simple handmilking to highly complex automated milking and cleaning systems for herds of several hundred cows. Fortunately the principles on which all the methods are based are the same and milk of the highest quality can be produced with the most simple equipment.

The operation of both simple and complex systems is described in two ways. The numbered pages outline the principles and methods of farm milk production and hygiene. The facing pages provide a running summary which draws the main conclusion from the text and with illustrations outlines the methods that farmers should use. Whilst these two parts of the manual are complementary the summary pages can be read separately to provide a guide to milk production methods.

For further information reference should be made to the more detailed texts listed, the publications of the International Dairy Federation and the commercial suppliers of milking and dairy equipment.

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FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
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CONTENTS

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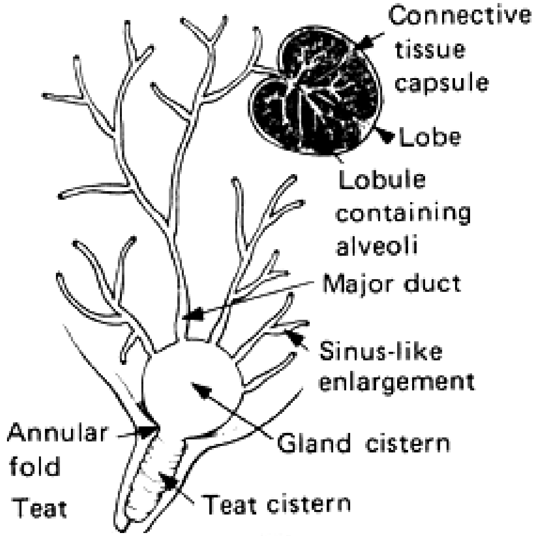
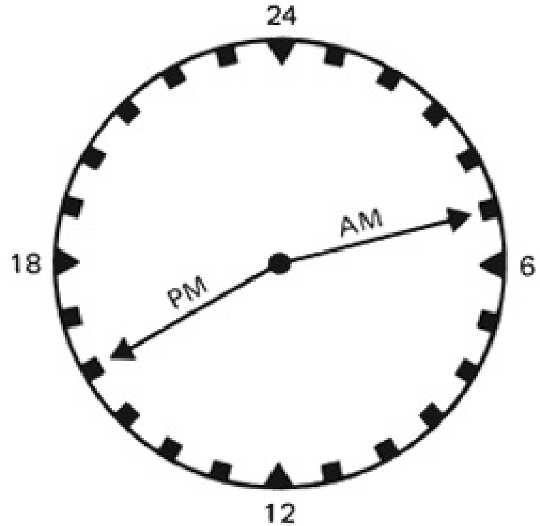
1. MILKING

MILKING - Lactation is the continuous secretion and storage of milk in the udder. The milk ejection or 'let-down' reflex effect is short term, inhibited by pain or fear but stimulated by good husbandry practices. Even so, at least 10% of secreted milk will be retained in the udder as residual milk. Removal of milk is achieved when external forces such as suckling or milking open the teat duct at the teat end.



MILKING INTERVALS affect the amount of residual milk carryover between milkings. Equal intervals of 12 hours give highest lactation yields but the effect of unequal intervals is small up to 16 and 8 hours and can be minimised if the highest yielders are milked first in the morning and last in the afternoon.



MILKING

Dairy farmers, with varying levels of skill, knowledge and resources, maximise returns from milk production by influencing lactation through selective breeding and control of reproduction, nutrition, disease and general management. The methods of milking have a particularly important effect because a cow cannot secrete over a period more milk than is

removed by milking. Thus, maximising milk removal in ways which are economic will take fullest advantage of secretion potential.

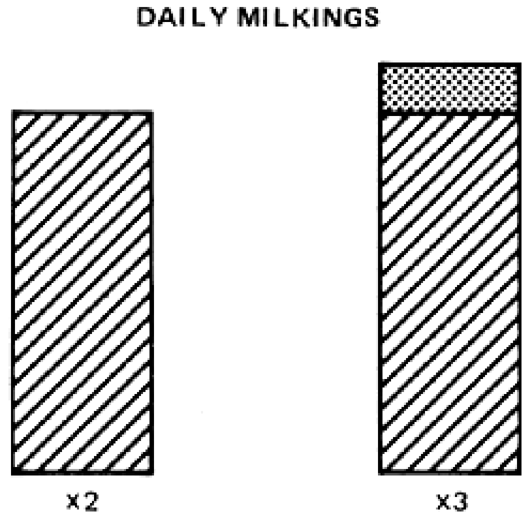
Lactation

Lactation includes both milk secretion and storage in alveolar cells and ducts within the mammary gland, followed by milk ejection (let-down) and milk removal. Milk secretion is continuous and usually at a constant rate for at least 12 hours resulting in a gradual increase in internal udder pressure. Milk ejection is a neuro-hormonal reflex initiated by various stimuli at milking time. These stimuli, which reflect good husbandry practices, are either natural (inborn) or conditioned (learned by experience), including, for example, feeding and udder preparation. They cause the alveoli and small milk ducts to contract forcing milk towards the udder sinus. Once this has happened most, but not all, of the milk can be removed when external forces such as suckling or milking open the streak canal (teat duct) at the teat end, but at least 10% will be retained in the udder as residual milk.

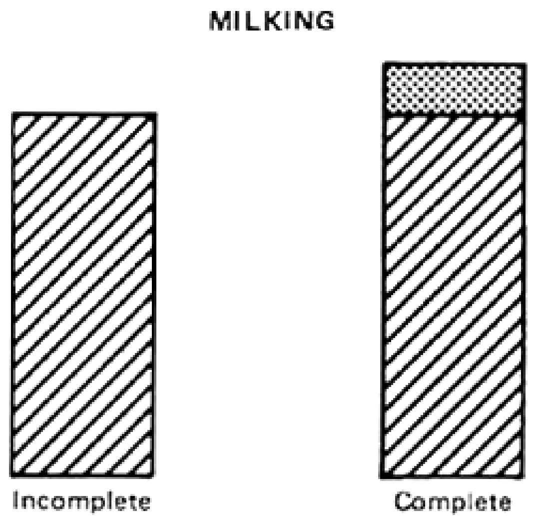
Milking intervals

The 10%–20% of the secreted milk which is not expressed from the secretary tissue and is retained in the udder when milking is completed is called ‘residual milk’ and has a much higher fat content than even the end-of-milking strippings. The quantity of residual milk is proportional to total yield, so that with unequal milking intervals there is a larger net carryover of milk fat from the longer night-time to the shorter daytime interval. This accounts for the apparent faster secretion rate and higher fat content of afternoon milk production. Milk yields, particularly from higher yielding cows are usually greater when milking intervals are 12 hourly. The effect of uneven intervals is not large up to 16 and 8 hours, and can be minimised by milking the higher yielders first in the morning and last in the afternoon.

MILKING FREQUENCY affects total daily production. Milking three times instead of twice daily will raise milk yields by an average 10%–15% but up to 10% of this increase will be required to cover extra costs. Chemical composition of milk is unaffected.



INCOMPLETE MILKING either from excessive amounts of residual milk or end-of-milking strippings can be avoided by effective milk ejection stimulation and by efficient fast milking by hand or machine.



Milking frequency

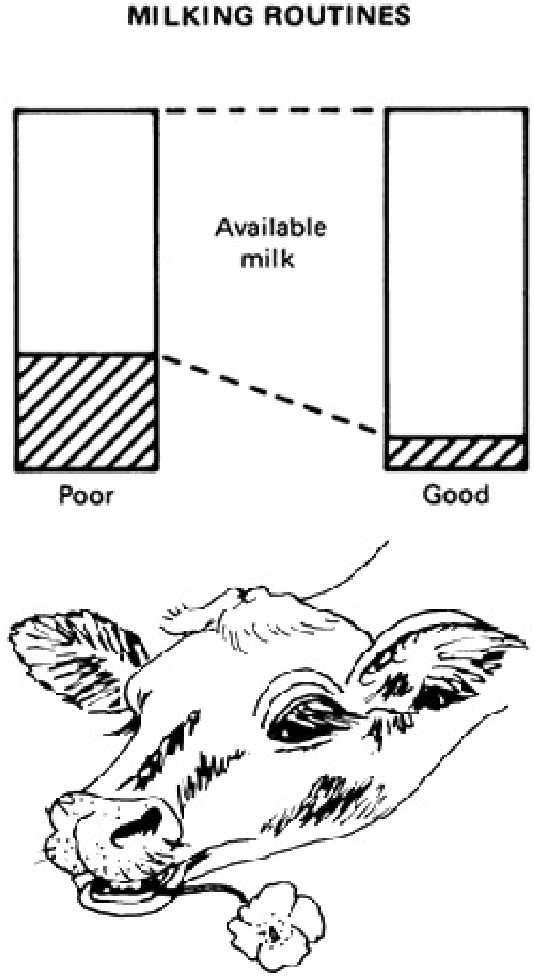
As a general rule, herd lactation yields will rise as the frequency of milking is increased. On average, the rise in milk yields will be between 10% and 15%, the largest increases occuring amongst heifers. The chemical composition of the milk (fat and solids-not-fat) will be unaffected. Recent commercial data from developed dairying areas also reveal that, on

average, up to 10% increase in yield is required to cover the extra costs of milking three times daily. The full benefit of the increased frequency is obtained by milking three times daily throughout lactation rather than reverting to twice daily when milk yields begin to fall. The reasons for the increase in lactation yields are inconclusive; the most likely being the more frequent removal of secretion inhibiting substances which begin the drying-off process.

Incomplete milking

There are two forms of incomplete milking. One is that excessive amounts of residual milk are retained in the udder because of inadequate milk ejection stimuli or the inhibitory effects of adrenalin secreted by cows becoming frightened and upset during milking, or even by slow milk removal. The other form is that some of the available milk is left in the udder when milking ceases, ie., the so-called 'strippings'. The modern milking machine is designed to remove 95% of available milk without recourse to additional cluster weight or manual assistance. Hand stripping, particularly with the finger and thumb should be avoided. The amounts of strippings are likely to be small even in relation to normal levels of residual milk and if not removed are unlikely to affect significantly either the lactation yield or quality of milk.

MILKING ROUTINES are a reflection of good stockmanship. Cows are creatures of habit; avoid any circumstances which upset or frighten them and so inhibit milk ejection.



Residual milk amounts will be inversely proportional to the strength of the stimuli signals. Develop a regular and repetitive milking routine. Make changes gently and carefully. Milk quickly and quietly in a stress-free environment.

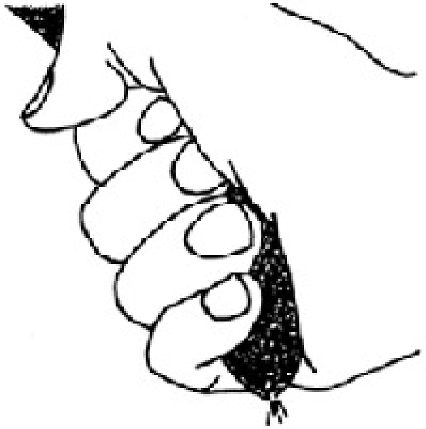
Milking routines

The aim of an efficient and effective milking routine is to leave the least amount of residual milk in the udder. This, in itself, is a measure of good stockmanship. Milk ejection can be stimulated manually by a series of activities carried out by the person doing the milking. The amount of residual milk is inversely proportional to the strength of the conditioned stimuli signals, which are developed into a regular, repetitive milking routine, including such activities as feeding and

udder preparation. The stimulation response is transitory, the maximum effect declining within a few minutes of milk ejection occuring. Therefore delayed milking will reduce the amount of milk removed. The internal pressure of milk within the udder peaks between one and two minutes after milk ejection and therefore milking should be completed as soon as possible after this occurs. Cows are creatures of habit and consequently changes to the routine should be made gently and quietly. It is important to avoid any circumstances which upset or frighten them causing the release of adrenalin which adversely affects the circulatory and musculatory systems, thus restricting effective milk ejection and prolonging the duration of milking. The response of cows and those milking them to a pleasant and stress free environment will be measured in terms of production levels.

Because residual milk and strippings have fat percentages that normally exceed 10%, incomplete or slow milking can reduce markedly the fat content of the milk at any particular milking. However, it is important to recognise that milk fat retained or left in the udder is not lost but will be obtained at succeeding milkings. In fact, although management factors (eg. varying milking intervals and milking frequency) may alter the fat content of milk at one milking, the average fat content over a period of time will be unaffected. On average, the fat content of milk obtained must be the same as that secreted into the udder. The concentrations of protein, lactose and other solids-not-fat are unaffected by changes in milking management either at one or more milkings.

HAND MILK with clean, dry hands. Use the full hand and avoid finger and thumb stripping.



MACHINE MILKING will create a pleasant sensation for the cows if the machine is kept clean, maintained properly and operated according to the manufacturer's instructions. Attach and remove clusters carefully to avoid vacuum fluctuations which cause mastitis. Readjust slipping teatcups and replace fallen clusters immediately.

Milking methods

Hand milking should always be done using clean, dry hands. Preferably, milk with the full hand and avoid end-of-milking stripping with the finger and thumb. Rear quarters should be milked first as they contain most milk and the milking bucket hooded to reduce contamination from dust and udder hairs.

Methods of machine milking are designed to create a pleasant milking sensation for the cows and to avoid any possible hazard to udder health. It is most important that milking is done with

a well designed, carefully cleaned and properly maintained machine which is operated strictly according to the manufacturer's instructions.

A skilled operator pays particular attention to careful cluster attachment and removal from the udder. During cluster attachment it is essential to ensure that the vacuum cut-off arrangements to the clawpiece are effective so that excessive volumes of air do not enter and cause vacuum fluctuations in the main vacuum pipeline system, as this could increase mastitis incidence. Attach each teatcup carefully starting with the two furthest from the operator. The clusters are removed as soon as milk flow ceases, avoiding excessive air entry through the teatcups by cutting off the vacuum supply before gently but firmly pulling the teatcups from the udder. During milking, any teatcups which slip from the teats should be readjusted immediately and any clusters which fall to the floor should be cleaned and reattached without delay.

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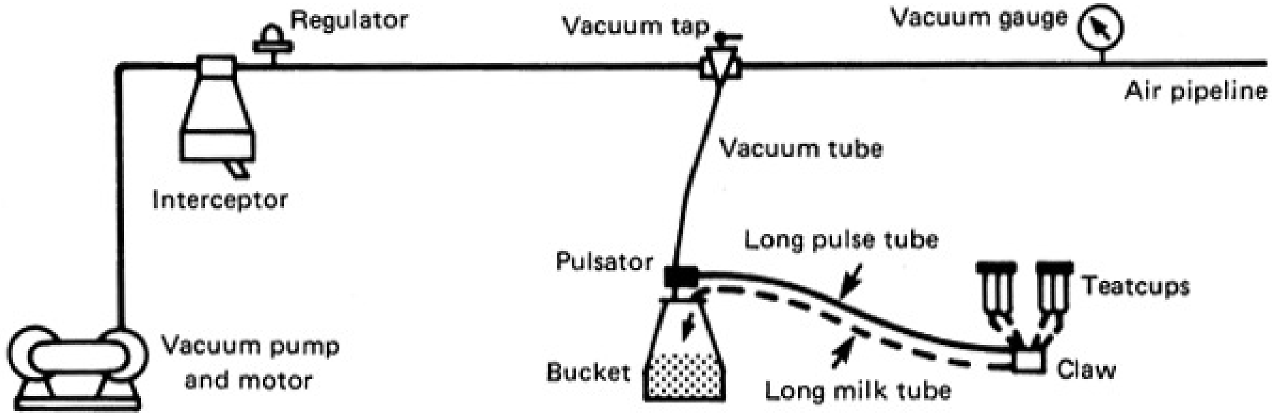
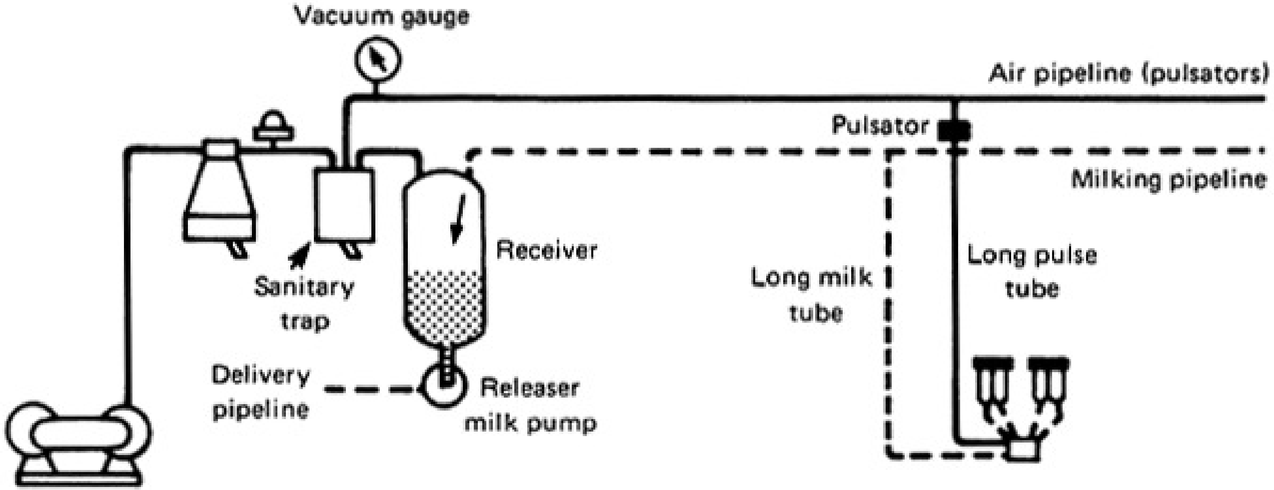
2. MILKING MACHINES AND EQUIPMENTS

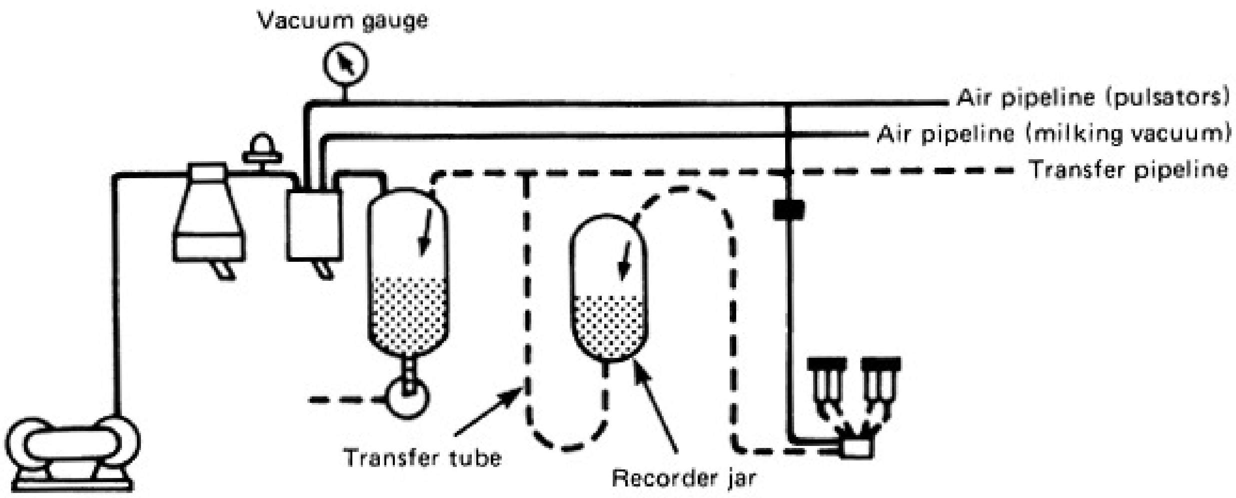
The basic layout of the three main types of milking machines are the same. Each has a pump to remove air from the vacuum pipeline, a vacuum regulator and a container to collect the milk that comes into the teatcup assembly during milking.



(a) Bucket (cowshed)



(b) Milking pipeline (cowshed and parlour)



(c) Recorder (parlour)

Principal types of milking machines

MILKING MACHINES AND EQUIPMENT

Basic construction

The <u>principle</u> of machine milking is to extract milk from the cow by vacuum. The machines are designed to apply a constant vacuum to the end of the teat to suck the milk out and convey it to a suitable container, and to give a periodic squeeze applied externally to the whole of the teat to maintain blood circulation.

A milking machine installation consists of a pipework system linking various vessels and other components which together provide the flow paths for air and milk. The forces necessary to move air and milk through the system arise from the fact that it is maintained at a vacuum. Thus it is atmospheric pressure which forces air, and intra-mammary milk pressure which forces milk, into the system and the combination of these forces causes flow. To be a

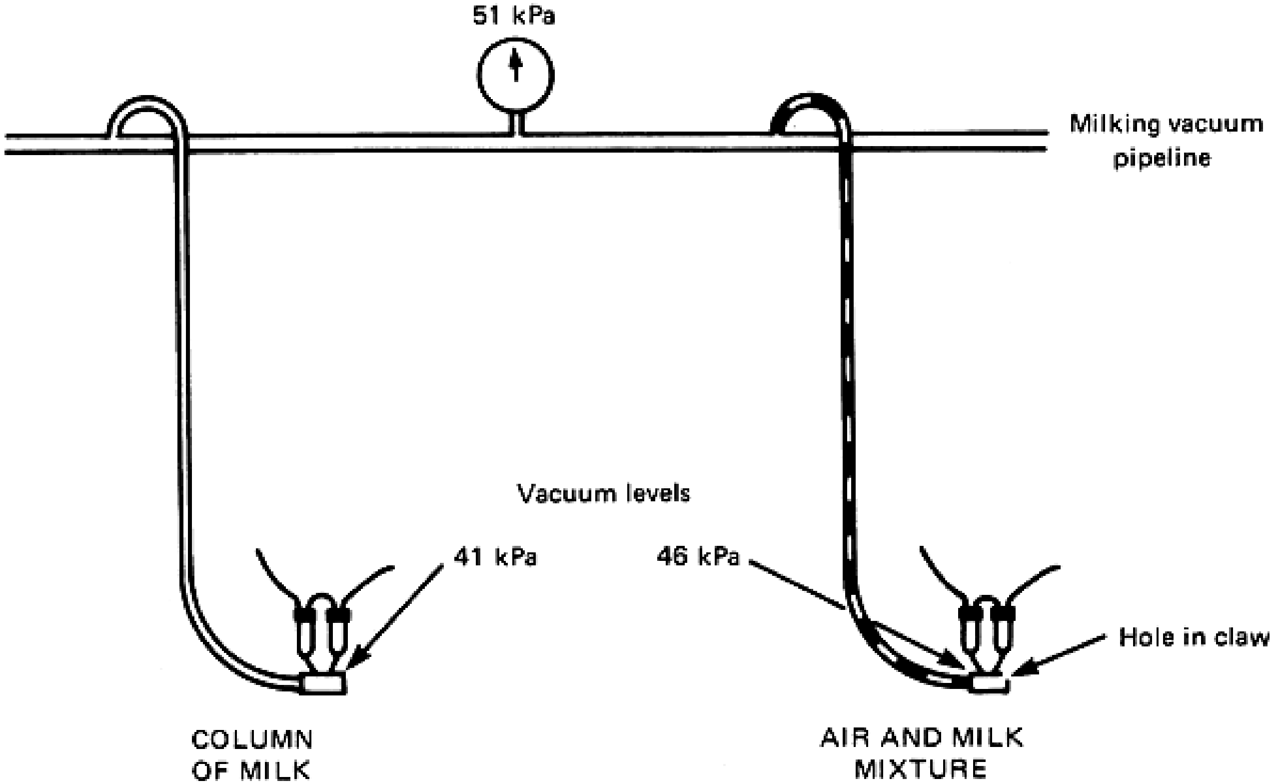
continuous operation it is necessary to remove air and milk from the system at appropriate rates.

Although milking machines have now developed into systems that show considerable diversity they have the same basic components. The air is removed by a vacuum pump at a constant rate. In a bucket or direct-to-can machine milk is removed from the system by disconnecting the milk container; in milking pipeline and recorder machines the milk is removed by a milk pump or releaser.

Fig. 1 shows the flow of air and milk through three basic types of machine during normal milking. In the bucket (or direct-to-can) machine the milk enters the teatcups and travels through the short milk tubes to the claw where air is admitted and the milk and air travel along the long milk tube to the bucket (or can). The milk remains in the bucket (or can) and the air separates to pass up the vacuum tube to the vacuum pipeline. The pulsator which is usually fixed on the bucket lid admits air intermittently and this passes along the long pulse tube to the teatcup chambers. To control the vacuum at a predetermined level air is also admitted to the system through a vacuum regulator which is fitted on the vacuum pipeline near to the milking points.

VACUUM AND MILK FLOW

When the milk from the claw is raised to a pipeline this can markedly reduce the vacuum at the teat because of the weight of milk in the long milk tube. The reduction in vacuum can be much reduced by bleeding air through a small hole in the clawpiece



In addition to the designed sources of air admission, air can be drawn into the teatcups past the teat and also when a milk container is changed or emptied. In a poorly maintained machine there may also be inward leakage of air at joints or points of damage. To maintain the working vacuum the vacuum pump extracts the air admitted into the system by compressing it so that it can be discharged to atmosphere.

In pipeline milking machines the flow pattern is similar to the bucket machine except that milk and air from each claw flow either directly to a recorder vessel where air and milk are separated, and/or through the milking pipeline to a common receiver vessel where milk and air are separated. There is no further air admission at this point when a motor driven releaser milk pump is used to empty the receiver. Other types of releaser (eg. pulsator controlled spit

chamber and double chambered weight operated) admit air.

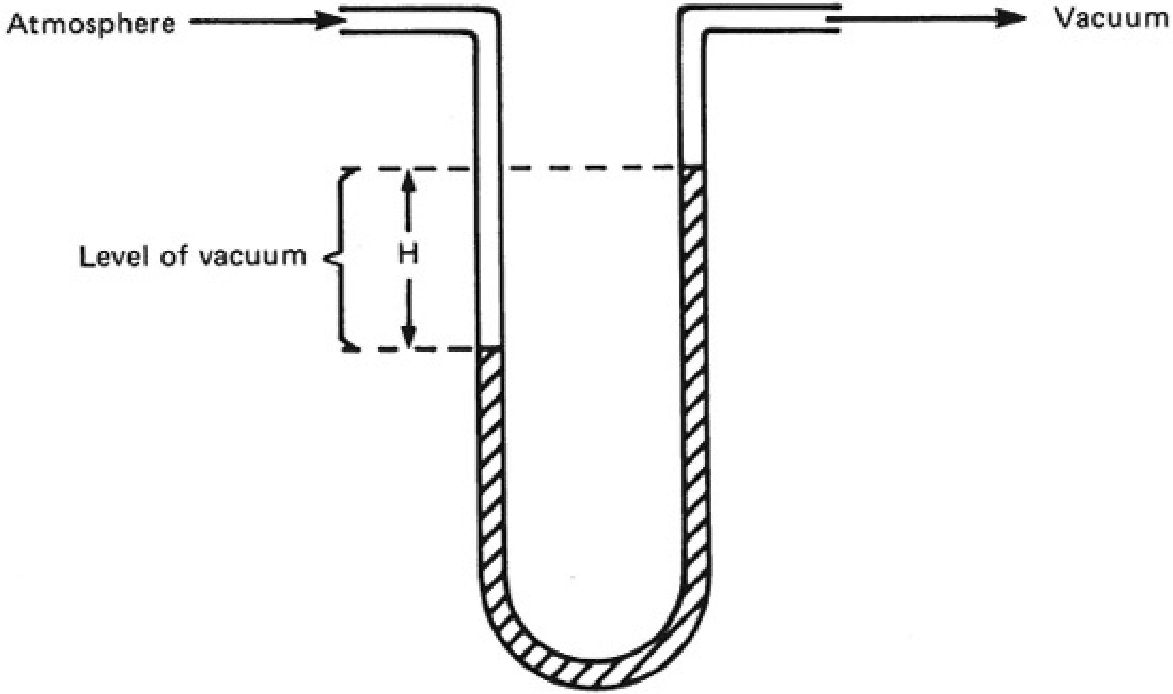
Where air and milk are transported together the flow pattern becomes complex depending on various factors particularly the volume of air relative to milk or air:milk ratio. Air is normally admitted in to the claw at a rate of 4 to 8 l/min. A milk flowrate for a fast milking cow will be about 6 l/min, giving an air:milk ratio of 0.7:1 to 1.2:1. Towards the end of milking when the milk flowrate has decreased to 0.25 l/min the ratio becomes 16:1 to 32:1.

The air:milk ratio becomes important where milk has to be elevated from the claw as in milk pipeline and recorder machines other than those with low level milk pipelines. Elevating a liquid, as distinct from a gas, involves a loss of potential energy and this is compensated for by a change of vacuum. Thus elevating a column of milk in a vacuum system through 1 m height reduces the vacuum by about 10 kpa. Therefore if the vacuum at the top of the column is 51 kpa it will be only 41 kpa t the bottom. This vacuum drop is markedly reduced by the admixture of air. If the air:milk ratio is 1:1 the weight of milk in the column is halved and the vacuum drop becomes only 5 kpa; if it is 9:1 the vacuum drop is only 1 kpa.

Under vacuum liquids cannot flow against gravity (ie. uphill) except as a column which fills the bore of the tube. Where the tube contains air and milk the liquid forms plugs which are separated by pockets of air in the proportion determined by the air:milk ratio.

VACUUM MEASUREMENT

Vacuum is a pressure below atmospheric pressure.



It can be measured as pressure difference with a mercury manometer in mm Hg (see diagram). The standard pressure is now kilopascals (kPa) with 100 kPa equal to the pressure difference between atmospheric pressure and absolute vacuum.

MEASUREMENT OF VACUUM

Vacuum is a pressure below atmospheric pressure, the term "negative pressure" is sometimes used but in milking machine terms it may be considered to mean "vacuum" measured on a scale in which atmospheric pressure at the time and place of measurement is zero vacuum.

Vacuum can be measured in a variety of units. A commonly used measure is the linear difference in height between two columns of mercury in a 'U' tube when one of the columns of mercury is subjected to a vacuum and the other open to atmosphere. (see diagram of 'U' tube).

The difference in height of the levels is supported by atmospheric pressure.

In the past the most commonly used units have been inches, millimetres or centimetres of mercury (in Hg, mmHg or cmHg). Units now adopted by the International Standards Organisation (ISO) for International Standards of milking machines for vacuum measurement are kilopascals (kPa) with zero (0) kPa being equal to atmospheric pressure and 100 kPa absolute vacuum. Equivalent relationships for values of vacuum levels are:-

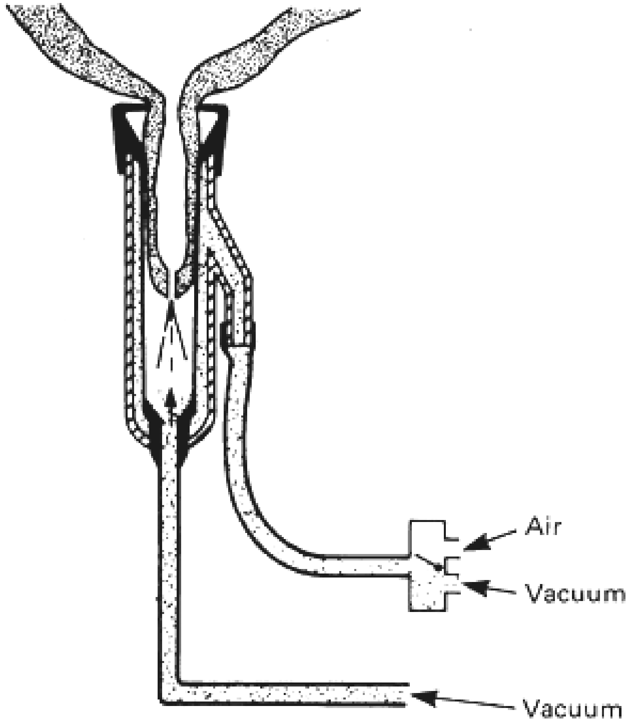
1 mmHg = 0.133 kPa
1 inHg = 3.386 kPa

Equivalents for vacuum levels of 50 kPa and 44 kPa that are the most commonly used levels for milking cows:

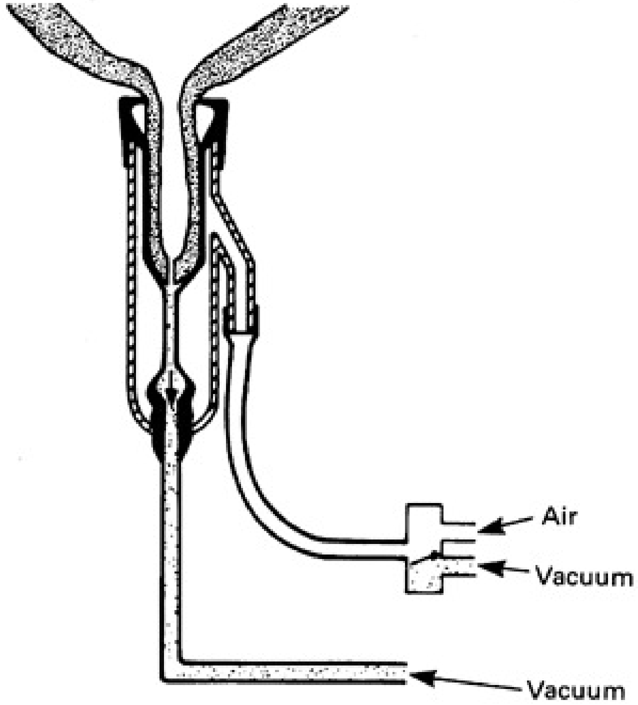
50 kPa = 14.8 inHg = 375 mmHg
44 kPa = 13.0 inHg = 330 mmHg

ACTION OF THE MILKING MACHINE IN EACH PULSATION CYCLE

Pulsator connects pulsation chamber to vacuum, liner opens and milk flows.



Pulsator connects pulsation chamber to atmosphere, liner collapses, squeezes the teat duct and prevents milk flow.



MILKING RATE

Milk flow from the teats increase with:

- **increasing vacuum but strippings also increase. (Normal vacuum range 40–50 kPa).**
- **increasing pulsation rate but this increases air to be pumped from the machine. (Normal rates 50–60 cycles/min)**
- **widening pulsation ratio, ie liner open to liner collapse time. (Normal range 50/50 to 70/30)**

TEATCUP LINERS

Teatcup liners have important effects on milk flow and completion of milking.

- **the liner mouthpiece affects the quantity of strippings**
- **narrow bore (<24 mm) and low tension (stretch) milk more slowly.**
- **choose liners appropriate for the size of cows teats to be milked.**

Action of the milking machine

The principles of machine milking were established many years ago and the basic method described below, is used in virtually all commercial milking machines although in a minority some modifications are made. The teatcup liner is the only equipment that comes into contact with the cows teats. The continuous vacuum within the liner causes the teat duct (streak canal) to open and the milk to flow because of the pressure difference between the milk in the teat and vacuum. To prevent damage or pain to the teat that would be caused by the continuous vacuum a system called pulsation is used. This makes the liners collapse on and below the teats about once each second massaging the teat and maintaining a more normal blood flow. In each pulsation cycle milk does not flow from the teat when the collapsed liner squeezes the teat duct.

Providing the cows 'let down' (ejection) has occurred the flow rate from the teat depends largely on the bore of the teat duct which is an inherent factor and not subject to management practices or training. Flow rates are also influenced by the mechanical properties of the milking machine. After the teat cups have been attached the flow rate reaches a maximum in about one minute, usually within the range of 2–5 kg/minute and the total milk flow period will range from 2 to about 8 minutes depending upon milk yield. Flow rates decline at the end of milking and when flow ceases there is usually a small amount of milk trapped in the sinus of the udder which can be removed by pulling ownwards on the clawpiece and massaging the udder (ie.

machine stripping). With modern designs of liner the quantity of strippings is small (ie. less than 0.3 kg) and machine stripping is not usually practiced. The small amounts of milk that are left do not affect milk yield or the average chemical composition of the milk obtained or mastitis.

VACUUM FLUCTUATIONS

The fluctuations in vacuum in the teatcup liner have important effects on mastitis and milk flow. There are two types.

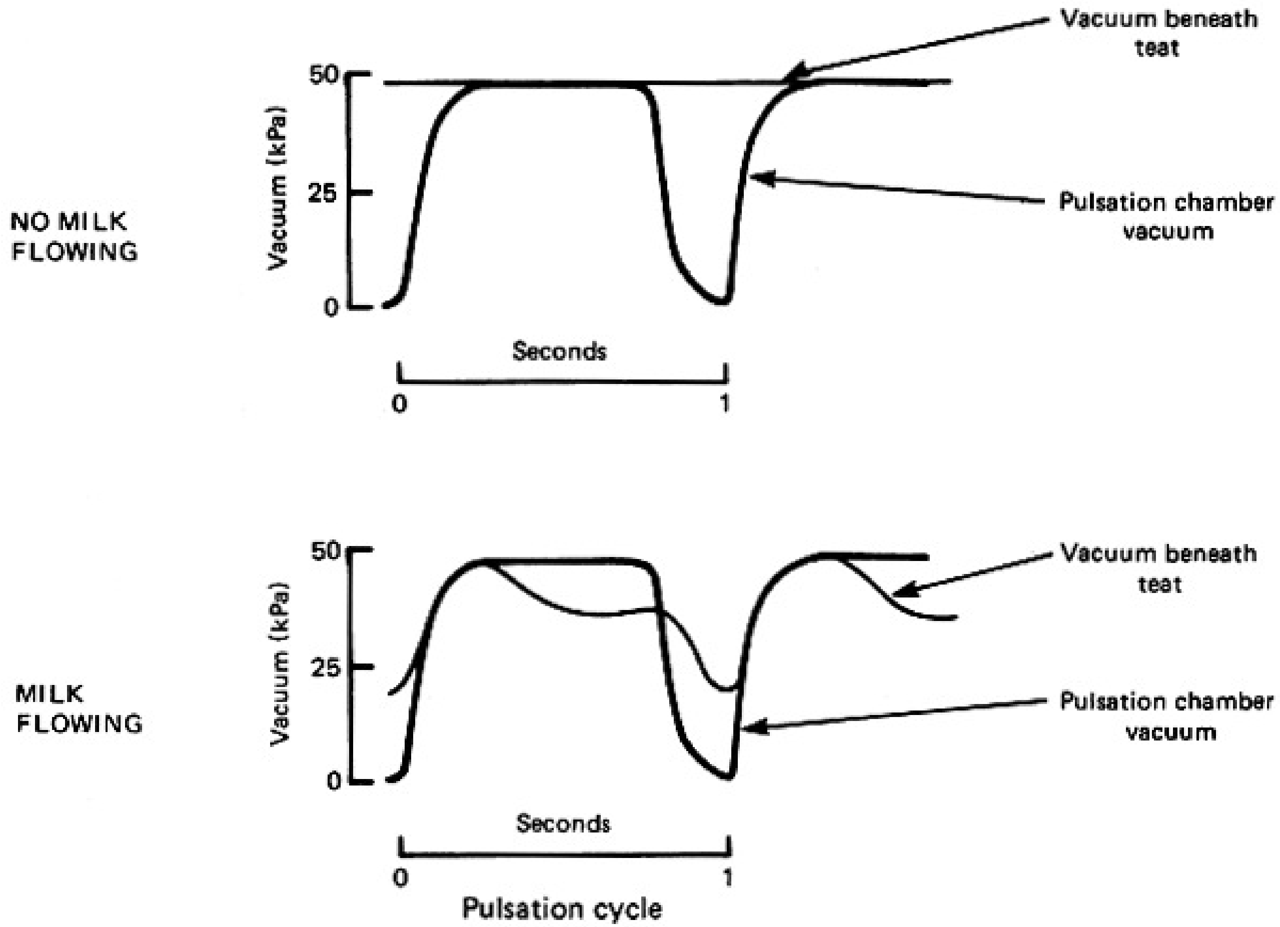
Irregular fluctuations

These occur when the teatcup liners slip or fall from the teats or air enters when milking units are changed carelessly. Vacuum recovery is slow if there is inadequate vacuum pump capacity.

Cyclic (regular) fluctuations

The cyclic movements of the liner in each pulsation cycle increase and decrease the volume of the liner under the teat. When milk is flowing this can cause marked changes in vacuum below the teat. This can be reduced by:

- **using wide bore short milk tubes (>8 mm)**
- **ensuring claw or short milk tube air bleeds are not blocked.**



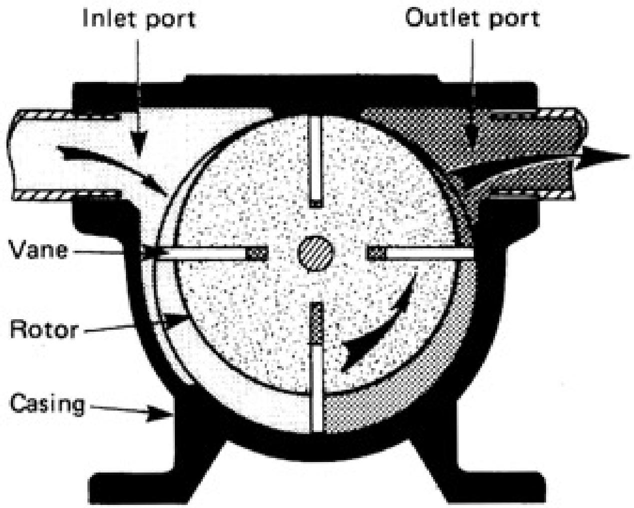
The main milking machine factor affecting milk flow rate is the liner vacuum. Raising vacuum levels gives faster milking but also increases strip yields and in practice a compromise level of about half atmospheric pressure is used (ie. 40–50 kPa, 300–375 mm/Hg). The pulsation characteristics also affect flow. An increased pulsation frequency (rate) gives faster milking but because this greatly increases the air admission in the machine and therefore the required pump capacity it is usual to keep <u>pulsation rates</u> at 50–60 cycles of liner opening and closing per minute. Because milk flow ceases in each <u>pulsation cycle</u> when the liner is collapsed on the teat, faster flow rates are obtained by using a wider <u>pulsation ratio</u> (ie. ratio of <u>liner open</u> time

to liner collapsed time). For udder health reasons the ratios are usually not greater than 70:30. The design of the liner can also affect the flow rate but modern liners tend to have similar flow properties. Narrow bore (<24 mm) liners and those with low tension in the barrel (ie. not stretched in the teat cup) milk more slowly. The most important characteristic of the performance of a liner is the amount of strippings left at the end of milking which is mainly determined by the dimensions and hardness of the mouthpiece. Liner design is largely empirical and farmers determine the best liners for minimum strippings by trial and error.

Although the teat cup liners are connected to a pipeline maintained at a constant vacuum level there can be considerable vacuum fluctuations in the liners, mainly due to the movements of the liner wall brought about by pulsation. When the liner is opening and the milk is moving away from the teat along the short milk tubes the vacuum below the teat will increase markedly due to the increased volume of the liner and the kinetic energy of the milk in transit. These variations in vacuum occur with each pulsation cycle and are called ‘cyclic fluctuations’. The fluctuations are increased with adventitious air admission that occurs when liners slip on the teats or when machines are removed from adjacent cows udders (irregular fluctuations). These cyclic and irregular fluctuations generate impact forces which are important factors causing mastitis. Various methods have been used to reduce fluctuations to prevent them having deleterious effects. The most important are the provision of adequate airbleed holes in the claw or short milk tubes to aid milk flow and prevent flooding in the liner. Also useful has been an increase in the internal diameter of short milk tubes (eg. greater than 8 mm). These can be reduced by other modifications. In some designs the basic system of machine milking has also been modified to give lower levels of vacuum at the start and end of milking when there is no milk flow or by the inclusion of a positive pressure phase in each pulsation cycle to give increased let down stimulation.

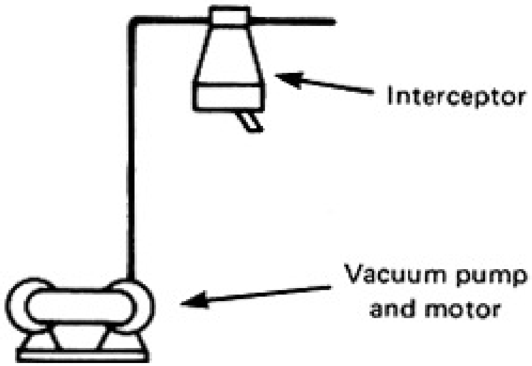
VACUUM PUMP

Most vacuum pumps are rotary oil sealed positive displacement pumps Air is drawn in through the inlet port by the rotation of the rotor, compressed and ejected to atmosphere.



INTERCEPTOR

A trap fitted in the main vacuum line to prevent liquid and dust being sucked into the vacuum pump



Components

VACUUM SYSTEM

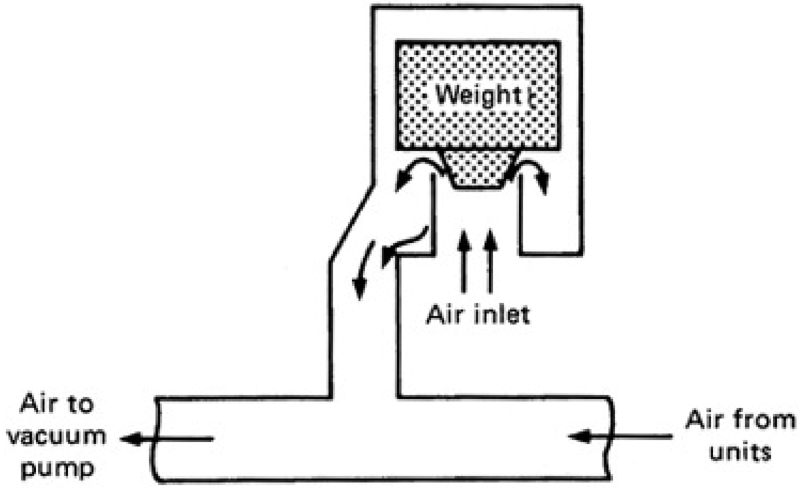
The function of the vacuum pump is to extract air from the pipeline system and in the majority of milking machines it is a rotary exhauster driven from either an electric motor or a stationary

internal combustion engine, using pulleys and V-belts. This gives flexibility with speeds ranging from about 800–1500 rev/min and a corresponding ange of pump capacities to suit several sizes of milking machines. A few vacuum pumps are direct shaft coupled; their speed is then motor speed and cannot be changed. When operating with a vacuum at the pump inlet suitable for milking cows (50 kPa), the pumping capacity should be sufficient for the total number of milking units connected. This will range from 70 litres of air per minute per unit for installations with 20 units to 85 per litres per minute for the smaller plants with 5 units.* It will vary according to individual manufacturers design of equipment and the additional ancillary components included. Oil lubricated high speed vacuum pumps operate at speeds of between 850– 1440 revs/min. For each 0.75 kW (1 h.p.) of rated electric motor requirement the extraction capacity is approximately 280 litres of air/min. The pump should be fitted with drive belt guards, an effective silencer and, for oil lubricated pumps, an oil separator. Also, a nonreturn valve should be fitted in the exhaust pipe to prevent reverse rotation of the vacuum pump when switching off at the end of milking. This is to avoid debris from the silencer/exhaust pipe being sucked back into the pump. To prevent solid and liquid material being drawn into the pump from the milking installation, an interceptor/trap vessel with a capacity of not less than 15 litres is fitted in the main vacuum line adjacent to the pump, with provision for draining and cleaning. It should also have a float valve to shut off the vacuum in the event of it filling with liquid.

* litres per minute are expressed as “free air”, that is air at standard atmospheric ressure at a temperature of 20°. In some countries the values may be given as “expanded air” or air under vacuum. At a vacuum of 50 kPa (ie. half atmospheric pressure) the values of “expanded air” will be approximately double those of “free air”.

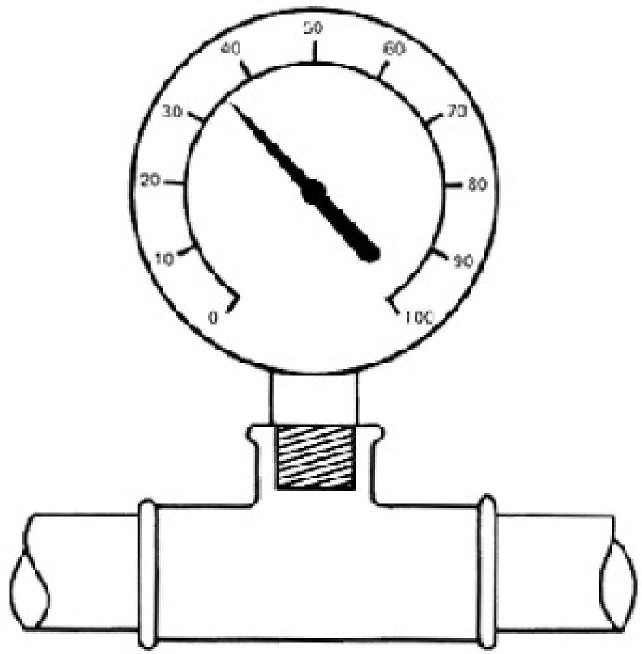
VACUUM REGULATOR

An automatic valve to maintain a steady vacuum inspite of varying air usage. A preset force (weight or spring) holds the valve closed until vacuum lifts it and allows air to enter. Valve should maintain vacuum to within the limits of ±kPa of the designed working vacuum.



VACUUM GAUGE

Indicates abnormal levels and fluctuations in vacuum, eg. serious air leaks, dirty regulator and slipping vacuum pump drive belts.

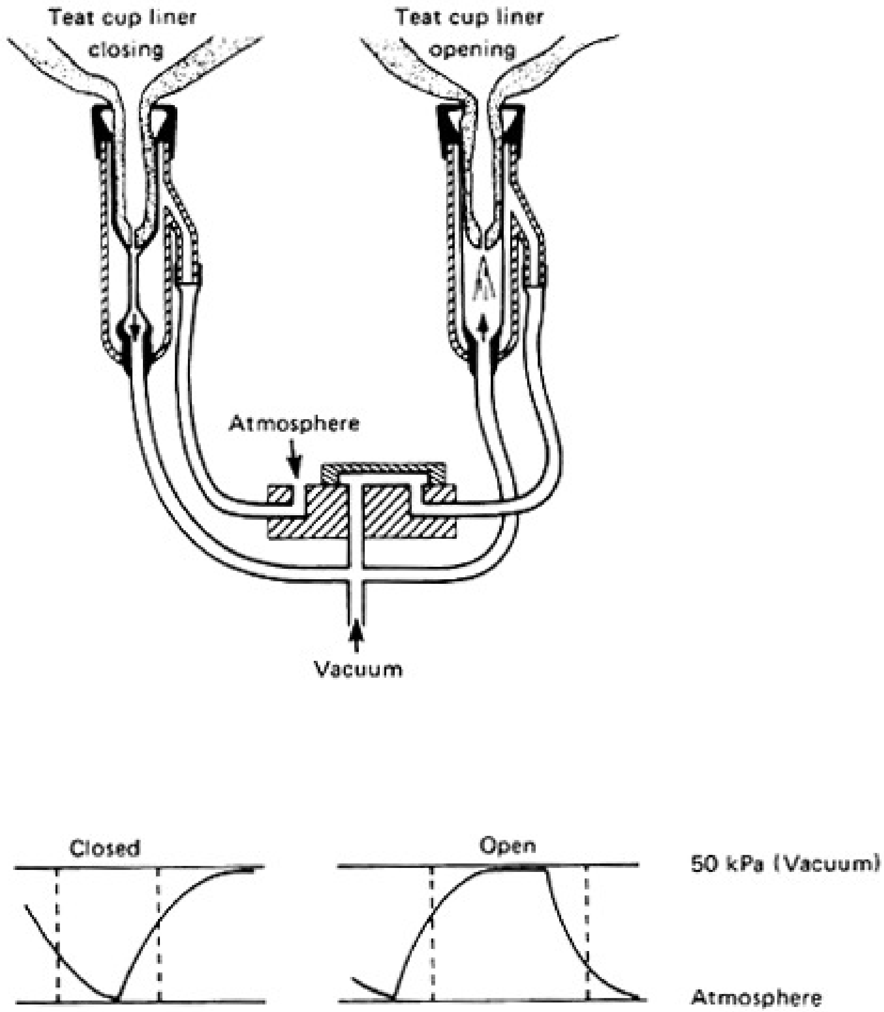


<u>Vacuum regulator</u> is an automatic valve fitted into the main vacuum pipeline near to the milking

units that is designed to maintain the working vacuum level in the milking machine, despite the varying air usage during milking. It operates by admitting air into the pipeline when the vacuum increases above the predetermined level. The valve is held closed by a weight or spring until the vacuum in the system overcomes the closing force, allowing atmospheric pressure to open the valve. Weight operated regulators have a maximum capacity of approximately 550 to 700 litres/min. Spring operated regulators have capacities of up to 1400 litres/min. Servo or power operated regulators, which usually have remote sensing, utilize a small intermediate pilot valve to actuate the main air inlet valve. These regulators sense pressure changes in the vacuum pipeline at a position where more stable conditions might be expected to exist. They are readily adjustable with capacities varying from 1000 to 5000 litres of air/min.* A good regulator should be able to control the vacuum to within plus or minus 2 kPa of the working vacuum, be stable and not leak by more than 35 l/min, when nominally closed. All vacuum regulators have an air filter to filter the incoming air. The vacuum gauge indicates the vacuum in the pipeline system. Its most important function is to indicate abnormal levels and fluctuations in vacuum, eg. serious air leaks, dirty regulator and slipping vacuum pump drive belts. Universally the Bourdon type gauge is used. It should not be less than 75 mm in diameter, graduated at intervals of 2 kPa and be adjustable. Most gauges have dual graduations, kilopascals (kPa) and millimetres of mercury (mmHg), and have lines on the dial indicating the working vacuum level.

PULSATORS

Pulsators are valves that cause the liners to open and close on the teat once each second (ie. pulsation) by connecting the pulsation chamber of the teatcup to vacuum or atmosphere.



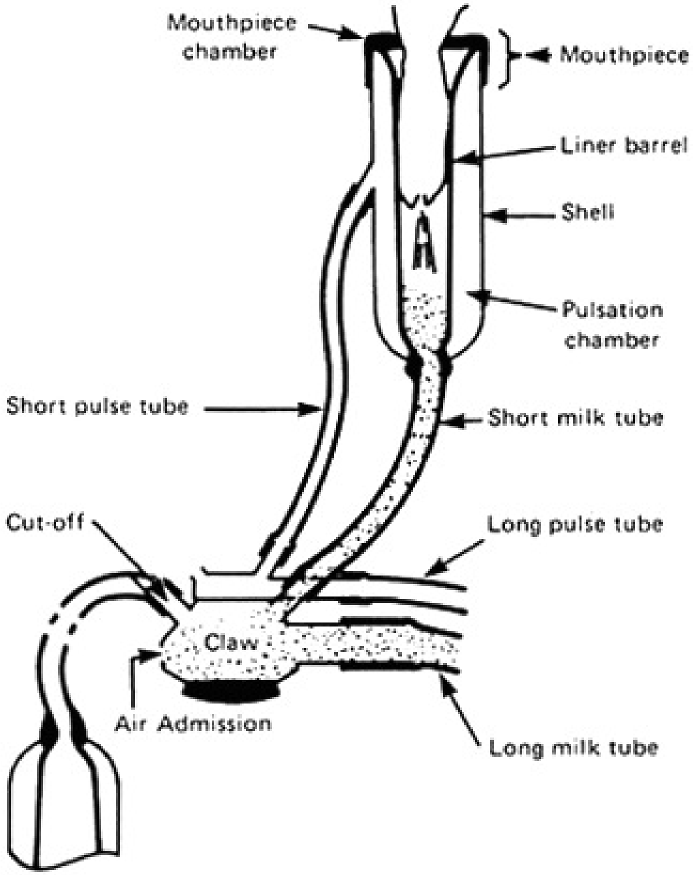
Pulsation chamber vacuum

The <u>pulsator</u> is a simple valve that alternately admits air and vacuum into the pulsation chamber formed between the rubber liner and he shell. This causes the liner to open and close during milking. The valve is activated either by a pneumatic (vacuum) or an electrical signal from a pulsator controller to give a frequency of 40–50 cycles per minute and a ratio (open to closed) of 1:1 to 2:1 (sometimes called 50:50 and 66:33). Relay pulsators are activated from a

central pulsator controller, and self contained pulsators have built-in controllers. Most relay pulsators, electrical and pneumatic, pulsate the four liners of a cluster together (simultaneous pulsation). Self contained pulsators are better adapted to pulsating liners in pairs with two open and two closed (alternate pulsation). In the slide valve mechanism of self contained pulsators, the slide valve is arranged to produce a predetermined ratio. With a higher vacuum under the teat than in the pulsation chamber (sometimes due to milk flowing downhill) the liner will not open fully, slightly pinching the end of the teat, resulting in possible teatend damage. Conversely elevating the milk can reduce the vacuum under the teat, with the result that the liner does not fully collapse. This will influence the designed ratio of open to closed of the liner. These adverse conditions are minimised by ensuring that there is an air admission hole into the bowl of the claw to admit air within the range of 4–10 litres/min as recommended in milking machine standards. The pulsation rate of pneumatic pulsators is determined by a restriction in the air or oil damping system of the pulsator. With all pulsators, the size of the valve ports, length and bore of the pulse tubes determines the rate of extracting and admitting air. This determines whether a pulsator can operate more than one cluster and is a function of the basic design. There are however solid state electronic pulsators that control the rate and ratio which provide alternate pulsation and can operate two milking units. Air filters are fitted in the air intake to prevent dust getting into the alve mechanisms which should not be lubricated unless recommended in manufacturer's instructions.

MILKING CLUSTER

Consists of four teatcup assemblies each having a rubber liner and connected to vacuum by rubber tubes and claw. The air admission hole to stabilise the vacuum must be kept clear.



Cross-section of a teatcup cluster

CLUSTER

The cluster which attaches to the cow, consists of four teatcup assemblies (each having a shell, a rubber liner and a short milk and short pulse tube), a claw, a long milk tube and long pulse tube(s). Teatcup shells are normally made of stainless steel. Plastics or a combination of plastics and metal are also used. The liner is a flexible rubber sleeve having a mouthpiece, and when assembled in the shell under tension, forms an annular space (pulsation chamber) between the liner and shell. This pulsation chamber is connected to the pulsator through a

nipple on the side of the shell via the claw. The teatcup assemblies are connected by short milk and short pulse tubes to the claw, which is connected to the milking and pulsation vacuum by a long milk tube and long pulse tube(s). To stabilise the vacuum in the teatcups during milking, the claw has a small air admission hole, about 0.8 mm in diameter, which admits approximately 7–8 litres of air/min into the bowl of the claw. This air helps to carry the milk away, preventing flooding and violent vacuum fluctuations. The claw is made of stainless steel or a combination of plastics and stainless steel, and usually weighs about 0.5 kg and the total all up weight of a milking cluster is about 2.5 kg. The weight of a milking cluster is important and the correct weight relates to the design of liners. Too little weight gives incomplete milking because of high levels of strippings, too much weight will result in milking units falling off during milking.

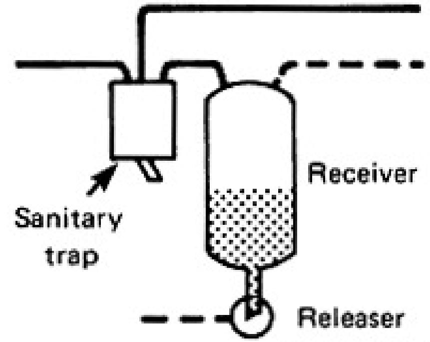
The bore of the rubber short milk tubes should not be less than 8 mm and the short pulse tubes not less than 5 mm, and the long milk tube should not be less than 12.5 mm. The effective claw bowl volume should not be less than 80 ml.

MILK AND AIR SEPARATION

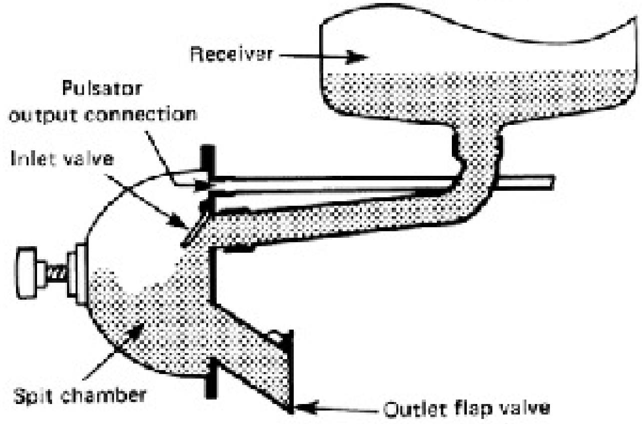
There are several methods of extracting milk from the vacuum system of pipeline milking machines.

The milk is collected in a receiver where the milk and air are separated ready to be extracted with:

a) a centrifugal releaser milk pump



b) double chamber releasers with weight or float operated mechanical valves and the New Zealand pulsator operated 'spit chamber' releaser



c. **direct connection to a refrigerated farm vat (bulk tank) that is designed to operate under vacuum eliminating the need for a conventional receiver releaser.**

MILK AND AIR SEPARATION

In pipeline milking installations it is necessary to include a method of extracting milk from the vacuum system. A receiver vessel is fitted to act as a milk reservoir and air separator and from this the milk is pumped out. It is made of either glass or stainless steel and may have a capacity of 35 to 160 litres or more depending on the method of cooling and storing the milk. During milking the weight or level of milk in the receiver is used to start the milk pump (releaser). Releaser milk pumps for extracting milk out of the vacuum system are: centrifugal,

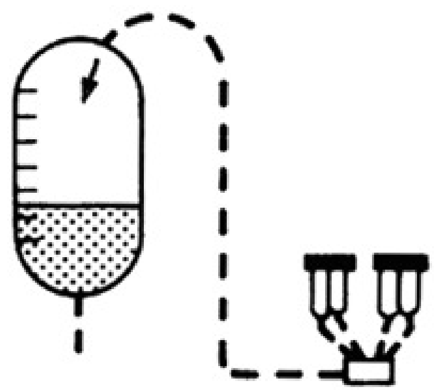
with capacities of at least 4550 litres per hour, or diaphragm, with capacities of approximately 2000 litres/hr for a single ended pump. Other methods for extracting milk from a vacuum system are double chambered releasers with weight operated mechanical valves and the 'spit chamber' releaser. These do not require electricity and the latter utilises a pulsating vacuum to alternately open and close flap valves allowing the milk to drain out of the second chamber.

In addition to the interceptor for the vacuum pump, a sanitary trap, is fitted in the vacuum pipeline adjacent to the receiver. This is a glass vessel of not less than 3 litres capacity that separates the part of the milking machine through which milk passes from the air system, preventing movement of liquid from one to the other. If milk enters the sanitary trap it is an indication of a fault in the machine. Therefore, it should be mounted within sight of the milker and be fitted with a float ball to shut off the vacuum. The vacuum connection between the sanitary trap and the receiver should slope away from the receiver to the sanitary trap.

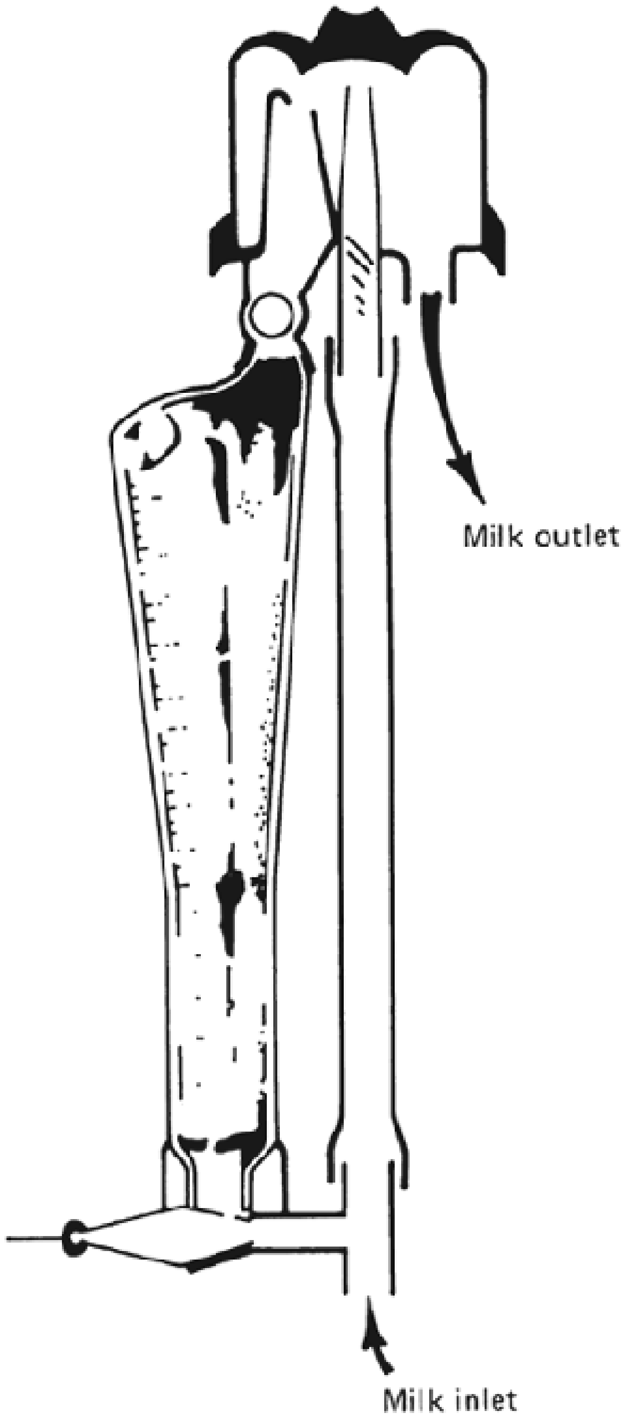
RECORDING AND SAMPLING MILK

To measure the yield of each cow requires:-

a) the milk to be collected in a calibrated glass recorder jar.



b) the milk to pass through a meter which can either take a constant proportion sample or to measure the whole yield in discrete batches and totalled.



All methods have provision for taking a representative sample of the total yield for milk quality (fat, protein and lactose) analysis.

RECORDING AND SAMPLING

In pipeline recorder milking installations, milk flows directly from the cluster into a rigidly mounted calibrated glass recorder jar *where* the milk is intercepted and held to allow measurement of the total individual cows milk yield. This is done by using either the calibrations etched on the side of the glass jar or the weight of the contents for jars that are supported on electrical strain beams.

In direct to pipeline milking machines not fitted with recorder jars, milk yields are measured with milk meters. There are several designs of meters. Basically there are two distinct methods used. (1) Proportional flow; these collect a constant proportion (about 2.5%) of the milk flow into a calibrated flask the contents of which are recorded manually or electrically. (2) Batch; the total flow of milk is continuously measured in discrete batches and the aggregate of the batches recorded.

Proportional flow meters used for manual recording are relatively simple and inexpensive. Electrical recording of milk yields, depending on complexity can be costly and are usually linked with electronic management data recording systems.

All these methods of milk recording have the facility for collecting a milk sample for chemical analysis and are required to be within set limits of accuracy for yield and ability to collect a true representative sample of the milk. These limits are laid down in an International Standard for milk yield recording equipment by I.C.R.P.M.A.*

*** International Committee for Recording the Productivity of Milk Animals**

MISCELLANEOUS EQUIPMENT

Milk flow detection

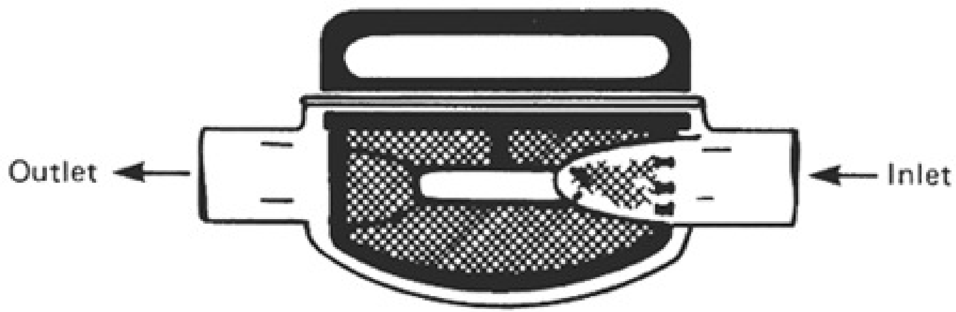
Devices are fitted to assist the milker to determine the end of milk flow.

These can be:

- **sight glasses or 'windows' in the claw or tubes**
- **glass recorder jars**
- **flow indicators which show visually when the flow rate falls below a definite level**
- **electronic equipment that measures change in flow rate**

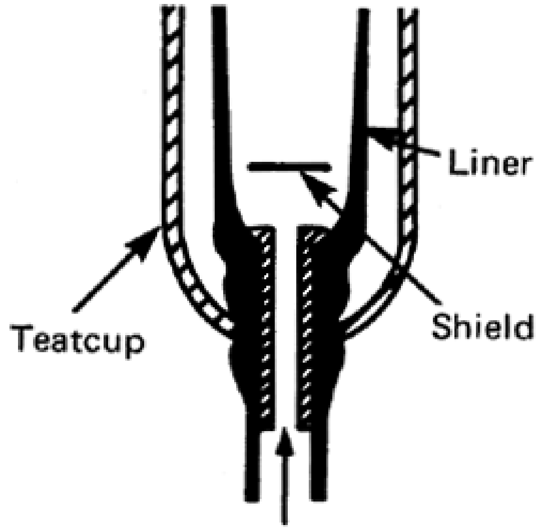
Mastitis detectors

- filters' in a transparent holder which indicate the abnormal milk



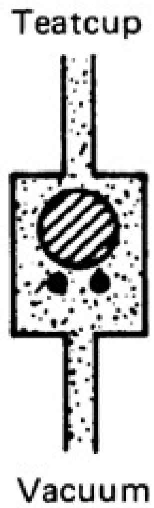
Teatcup liner 'shields'

These are fitted in the teatcup liners to reduce mastitis by preventing contaminated milk droplets impacting the teat ends when the vacuum fluctuates in the liner.



'One-way valves' (Non-return)

These are fitted in the claw, in the short milk tube or in the teatcup liner to reduce mastitis by preventing reverse-flow of milk



MILK FLOW DETECTION AND CLUSTER REMOVAL

With all milking units, except those using transparent recorder jars, there is some provision

made for observing milk flow. This can be a metal claw fitted with "windows", or a claw made in a transparent material or, a short length of clear tubing fitted in the long milk tube. Observing flow in these ways can be misleading and there are now milk flow indicator devices that work on the basis of milk flowing into a small container with a submerged metering orifice for maintaining a milk level. Variations in this level can be observed or detected electrically, using a magnetic float switch or electric probes.

In modern large milking installations, milk flow detectors are used to sense the end of milk flow (less than 250 g/min) and activate automatic cluster removal (A.C.R.) equipment. This equipment prevents overmilking and enables the operator to use more units by reducing the workload. It eliminates waiting to observe when an animal has finished milking and manually detaching the cluster. Electrically operated milk yield recording equipment eg. glass recorder jars on strain beams and milk meters can be used as flow detectors and linked to A.C.R. equipment. In this way the milking cluster is removed when flow rate has fallen below a predetermined level. A useful device that can be fitted in the long milk tube is a small in line filter used as a mastitis detector. It retains milk clots enabling clinical mastitis to be detected and also acts as a coarse filter for removing extraneous material which is an advantage when using flow detectors or milk meters that have small metering orifices etc. The filter screen is easily removed for rinsing off the clots after each cow and the detector is cleaned in situ by the normal cleaning system of the milking machine.

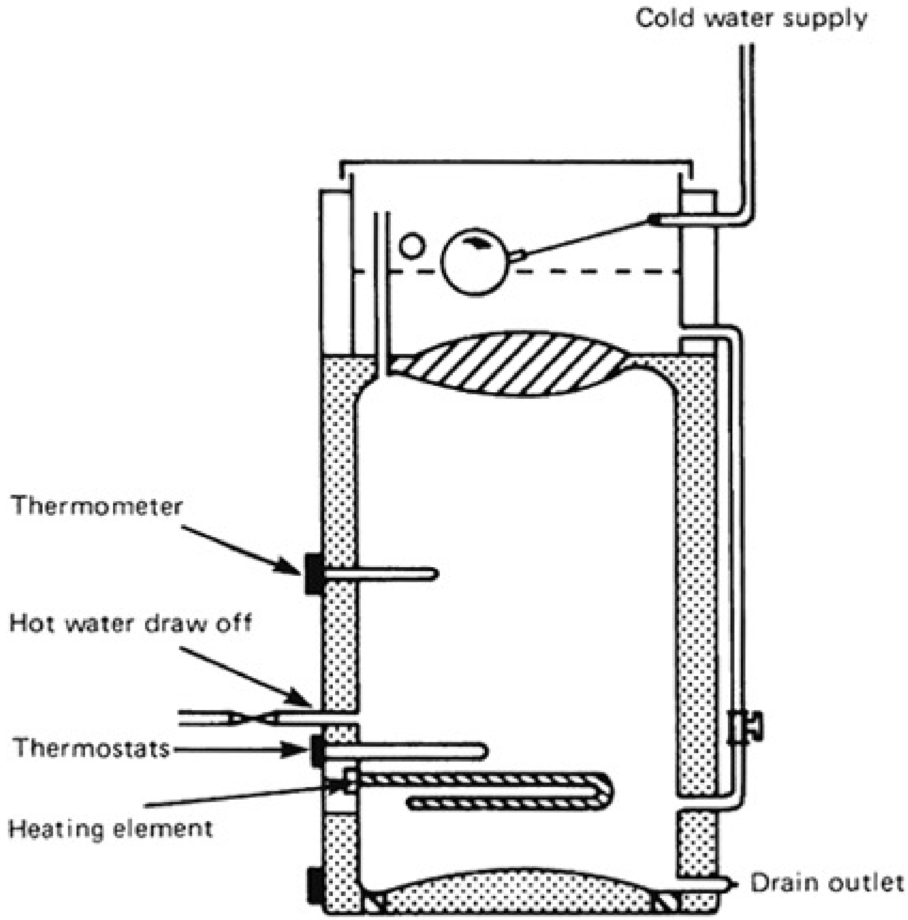
To reduce or eliminate the effect of vacuum fluctuations that occur during milking "shields" can be fitted in the bottom of the liners near the outlet preventing contaminated milk returning up the short milk tube from impinging on the teat end. The shield consists of a disc of stainless steel or plastics of a diameter that leaves a space etween the edge of the disc and the liner wall not less than the internal diameter of the milk outlet. A more positive method to prevent the reverse flow in a conventional cluster is to fit non-return valves in the claw or short milk tubes

together with a small air admission hole between the liner and the valve to maintain normal milk flow. A system of milking with non-return valves but without the air admission holes has been investigated and preliminary results show the development could have advantages.

WATER HEATERS

The quantity of hot water required depends on the size of milking machine and the cleaning methods used. It is essential to have an adequate supply. The methods of heating can be, a solid fuel or oil fired boiler, an open top un-insulated electrical wash boiler or a self contained insulated electric water heater. Complete with time switch, thermostat and automatic water filling.

The electrical heating element should be fitted with a clear space beneath it for the hard water scale that will collect.



WATER HEATING

For nearly all milking machine cleaning methods an adequate supply of hot water is necessary. Water heaters vary from simple free standing insulated or uninsulated tanks filled with a hose and manual control to insulated tanks automatically filled and heated at predetermined times.

The water capacity required is dependant on the washing system used (hand or in-place cleaning) and the number of units to be washed. For in-place cleaning the amount of water

required for each milking unit will be 12 literes of water at 85°C for recirculation cleaning and 18 litres at 96°C for a single pass "boiling water" cleaning system. Additional hot/warm water may be required for udder washing and calf feeding. Whatever cleaning methods are used the water heater should be capable of producing near boiling water for the purpose of giving the installation a periodic heat treatment. The temperature of the wash solution in closed pipe work is affected by the vapour pressure of the liquid. Water at normal atmospheric pressure at sea level boils at 100°C (212°F) and at a vacuum of 50 kPa (14.8 inHg) it boils at 81.7°C (179°F). Thus when cleaning pipeline milking machines with water solutions under vacuum, the maximum temperature which can be obtained ill depend on the operating vacuum level in the installation, ie., the higher the vacuum level the lower will be the temperature that can be obtained. For similar reasons, at an altitude of a 1,000 metres where atmospheric pressure is reduced to about 89 kPa (12.9 lb/in2), water in an open vessel will boil at the lower temperature of 96°C (205°F) instead of 100°C (212°F) at sea level.

Although any fuel can be used for water heating the most commonly used is electricity for cleanliness and convenience. In areas with hard water supplies, a hard scale will build up in the tank and on the heating element. The electrical heating element should be fitted with a clear space beneath it (approx. 10 cm) and be of a type that will flex during heating and cooling, breaking off the hard water deposits that will fall into the space below. Provision should be made for easy removal of this accumulated scale.

For economy any water heater should be well insulated, fitted with a thermostat and preferably a time switch. In soft water areas tanks that are manufactured in galvanized sheet metal are not suitable and copper should be used.

MAINTENANCE

For effective milking giving good yields of high quality milk, fast milk removal and to minimise mastitis, good milking machine maintenance is required. Maintenance routines should be provided by the manufacturers of the equipment.

These will include

- **simple checks to be made immediately before each milking**
- **checks at weekly and monthly intervals**
- **an annual check of the complete plant by a trained technician.**

FAULTS FOUND MUST BE CORRECTED

Otherwise the checks are of no value.

Maintenance

The basic layout and operation of milking machines is normally straight-forward and similar for all standard milking machines. However, it is important that a correct maintenance routine is followed. Faulty milking machines can result in poor milk let down, slow milking, milk of high bacterial count and mastitis. Maintenance is a responsibility of the person regularly using the equipment with simple checks made at each milking and more detailed ones at weekly or less frequent intervals.

The maintenance instructions described deal with the essential routines and do not include checks on the many optional items not fitted in large modern parlours, (eg. automatic cluster removers, milk meters). These vary considerably and the maintenance procedure should be obtained from the supplier. Because the overall performance can be assessed only with special measuring equipment a fullscale test should be carried out by the manufacturer, installer or

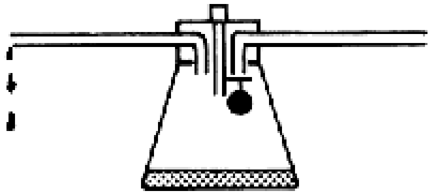
extension service at least once per year.

The following routines should be read in conjunction with maintenance procedures provided by the suppliers of the milking equipment.

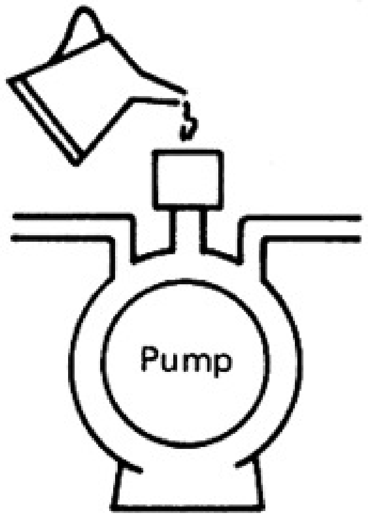
MAINTENANCE CHECKS

At each milking

- check pipelines and interceptor are free from milk or water, if found, drain and flush with chlorinated water (100 ppm)

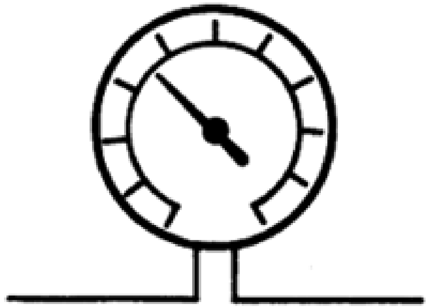


- check for water behind teatcup liners if found drain

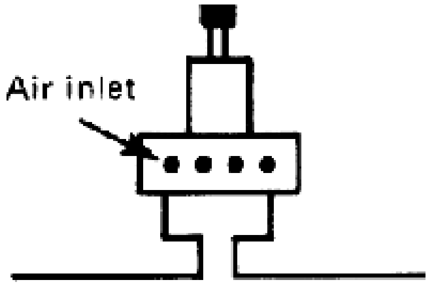


check oil level in pump, if necessary top-up to correct level

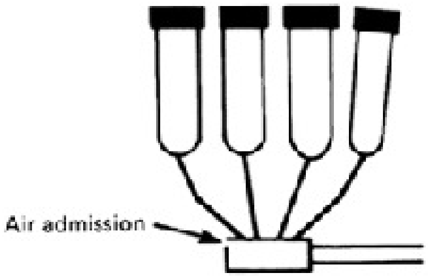
- check vacuum level and rate of recovery, if level too high check vacuum regulator, if recovery is slower than usual to reach working level, look for leaks into machine



- during milking listen to ensure that regulator is continuously letting air into the vacuum system



- check air admission hole in claw is clear



At Each Milking

Confirm that <u>wash water</u> is <u>not retained</u> in <u>milking</u> <u>machine pipelines</u>, particularly the milk lines. This water is likely to have a high bacterial count and reduce the quality of the milk. If water is found drain and flush the milk lines with hypochlorite solution (100 ppm) before milking. In most countries it is an offence to add water to milk and residual water in a milking machine may be sufficient to fail the freezing point of milk test. With some machines and washing

systems water can enter the pulsation chambers of the teatcup, damage pulsators, affect the pulsation of the liner and gain entry into the main vacuum systems giving high levels of bacterial contamination. Check the clusters for split liners.

Before starting the vacuum pump confirm that the interceptor is empty either by opening the drain valve or detach the trap for inspection.

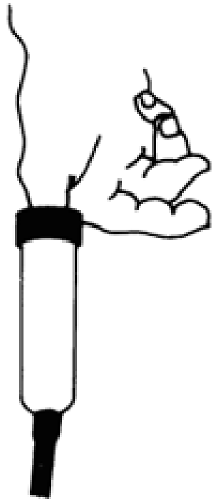
Confirm that the oil level in the vacuum pump oiler is at a satisfactory level, ie., not less than half the capacity of the oil reservoir.

Observe the vacuum gauge, the working level should be reached within five seconds, or consistant with the time stated by the manufacturer when the equipment was installed. If there is a delay bove that expected, check for air leaks at open stall or drain cocks, a misplaced receiver or bucket lids and where a centrifugal milk pump is used, for failure of the non-return flap valve to close. If all these items are in order check that the vacuum pump drive belts are not slipping. The working vacuum should be constant and the reading on the vacuum gauge should be the same before and after putting the milking clusters on the cows. Faults found should be corrected at the earliest opportunity.

MAINTENANCE CHECKS

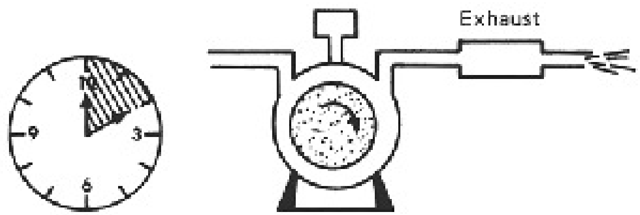
At each milking (continued)

- listen to ensure normal sound from pulsators. Check suspect action with thumbs in teatcup liners

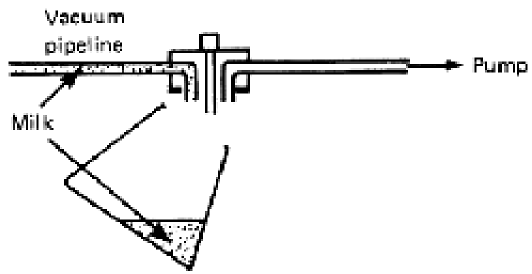


After each milking

- allow pump to run for 10 minutes after end of milking



- check for milk in interceptor. If found find cause and wash out pipeline and interceptor with a warm detergent solution.



When all units are in operation and the working vacuum is correct, <u>listen to the vacuum regulator</u>. If there is no sound of air entering the regulator, a serious shortage of pump capacity is indicated. If on starting the vacuum pump the vacuum level rises first to a high level then drops to the working vacuum level the regulator is sticking and requires cleaning.

<u>Check operation of the pulsators</u>. The sound from the pulsators should be regular. When noise

is abnormal look for damaged/split rubber pulse tubes particularly at the nipples on the claw, or faulty pulsators. If there is any abnormality check pulsation of liners with thumbs (see Weekly Check).

Examine the milking cluster for damaged rubberware, particularly the short milk and air tubes at the claw nipples.

Condensation or moisture from milking or plant cleaning can collect in the vacuum pump. This rusts the pump body producing, a condition which reduces performance and ultimately would require pump eplacement. This can be avoided by allowing the pump to run for approximately 10 minutes after milking to exhaust the moisture and dry out.

After switching off the vacuum pump examine the interceptor. If milk is found in the interceptor, this may indicate a split liner or malfunctioning of the milk pump. Find the cause, wash out vacuum line and interceptor.

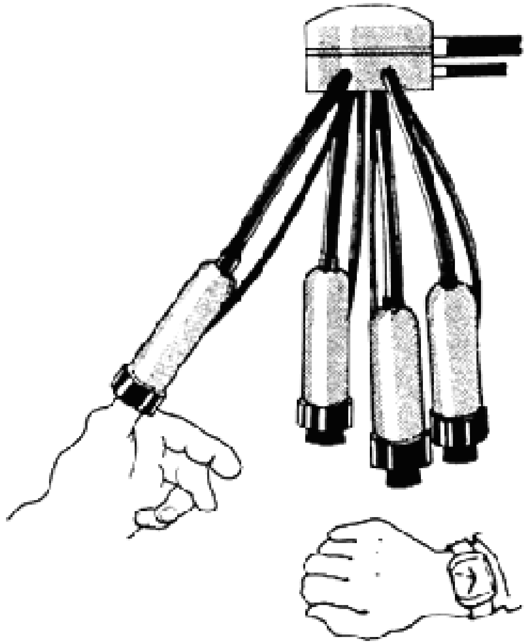
MAINTENANCE CHECKS

Weekly

- check pulsator action of all clusters with thumbs in teatcup liners

a) for pulsation ratio of squeeze to release

for number of pulsations per minute



Inspect all rubber tubes for kinking, flattening or damage, in particular short pulse tubes and milk tubes for holes, replace if necessary.

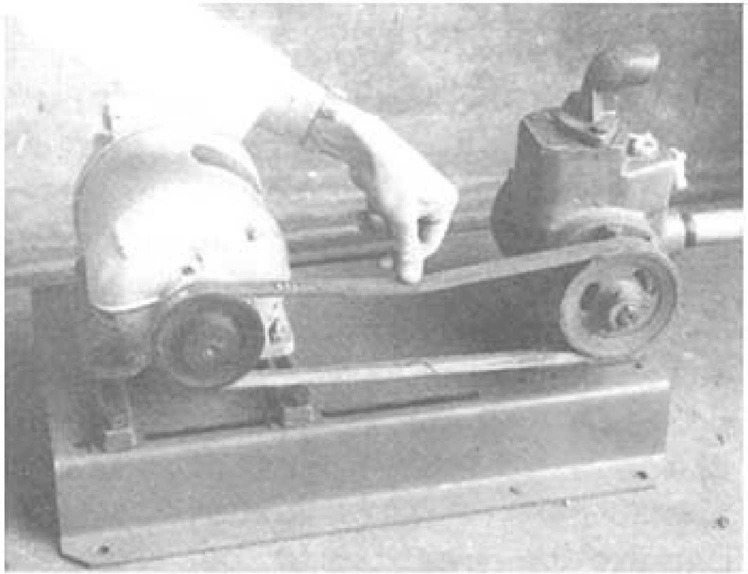
WEEKLY

To test the pulsation and liner wall movement use the thumbs to sense the movement of the teatcup liner walls. This is done by inserting the thumbs into diagonal pairs of teatcups in turn with the others hanging in the cut-off position; the controls being set for milking. To make certain that the pair of teatcups not being checked are sealed they can be closed with rubber plugs (bungs). With experience abnormal action of the liner is readily detected. If the liners open and close completely and the action of the machine is not painful it will normally be satisfactory for milking. Failure to collapse indicates that the air inlet to the pulsator is blocked or that the pulsator valve is not working properly and the pulsator must be replaced. If this is discovered the operator will find that the cows are uncomfortable and restless and kick

clusters off. The ratio of the liner open to closed cannot be confirmed by this test but it should be possible to detect that the collapse or closed phase is shorter than the open, milking phase. If the pulsation appears to be unsatisfactory check for damaged short and long air tubes.

When checking the liner wall movement confirm that <u>the speed of pulsation is correct</u>. Slow pulsation will give longer milking times. In self-contained individual pnuematic pulsators this slow action is usually due to a low vacuum level or a dirty slide valve. Some designs f pulsators have a speed adjustment facility, this should be reset if incorrect. Most designs of pulsators are designed to operate in the range of 50–60 pulsations per minute. The pulsation speed can also be checked during milking by a slight pressure on a short pulse tube with thumb and fore finger.

- a slack vacuum pump drive belt will result in wear and loss of vacuum. Check tension by deflecting belt, movement should not exceed 15 mm (0.6 in). Also check oil level in vacuum pump oil reservoir and refill.



- inspect air filters on pulsators and vacuum regulators. Clean off light dust deposits by brushing or blowing. Heavily contaminated foam plastic filters should either be renewed or washed in warm detergent solution.

VACUUM PUMP DRIVE BELT AND OIL LEVEL OF PUMP

Check the Vee drive belt tension on vacuum pumps. Deflect the belt downwards at a point midway between the pulleys. The movement or deflection possible from the rest position should not exceed 15 mm (0.6 in). A slack drive belt will slip, reducing the vacuum pump performance. If serious belt slip is occuring there will be visible particles worn from the belts on the floor. If adjustment is needed care should be taken to keep the pulleys in alignment. Check the oil level in oil reservoir and if necessary refill.

FILTERS

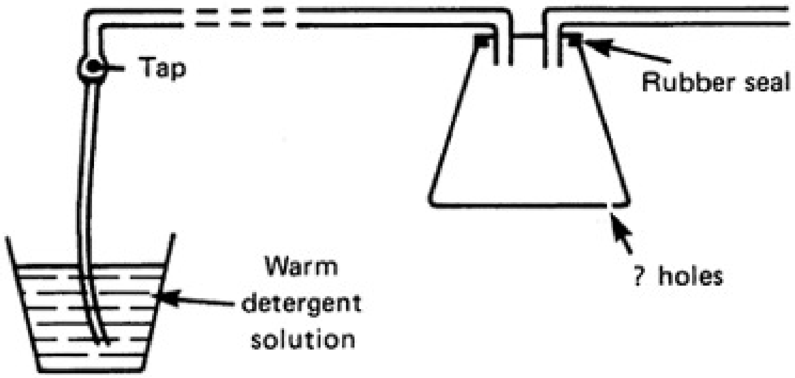
Air filters on pulsators and vacuum regulator must be kept clean. The frequency of cleaning depends on whether they are operating in a clean or dusty environment. Most modern components are fitted with foam plastics air filters or screens. Brushing or blowing will remove light dust deposits. Heavily contaminated foam plastics filters should either be renewed or washed in a warm detergent solution and thoroughly dried before re-assembling into the pulsator.

Monthly

-dismantle and clean weight operated vacuum regulators. Using a soft brush and a solvent, methylated spirit. Taking care not to damage valve surfaces.
Remote sensing regulators

- follow manufacturers instructions.

- wash out vacuum line and interceptor, using hot detergent solution and drain. At the same time check interceptor for leaks, from rubber seals or small holes in base.



MONTHLY

Dismantle <u>weight operated vacuum regulators</u>, clean valve face and valve seat with a solvent (methylated spirit). Care must be taken to avoid amage to valve surfaces. Remove difficult deposits with metal polish. Clean regulator filter before the regulator is reassembled and ensure that the weight is evenly balanced.

<u>Servo or power operated</u> remote sensing designs of regulators should be serviced according to the manufacturers instructions as correct reassembly is not always easy. They will require the conical valve face to be cleaned and rubber diaphragm(s), if applicable, inspected. DO NOT oil valve or valve guides.

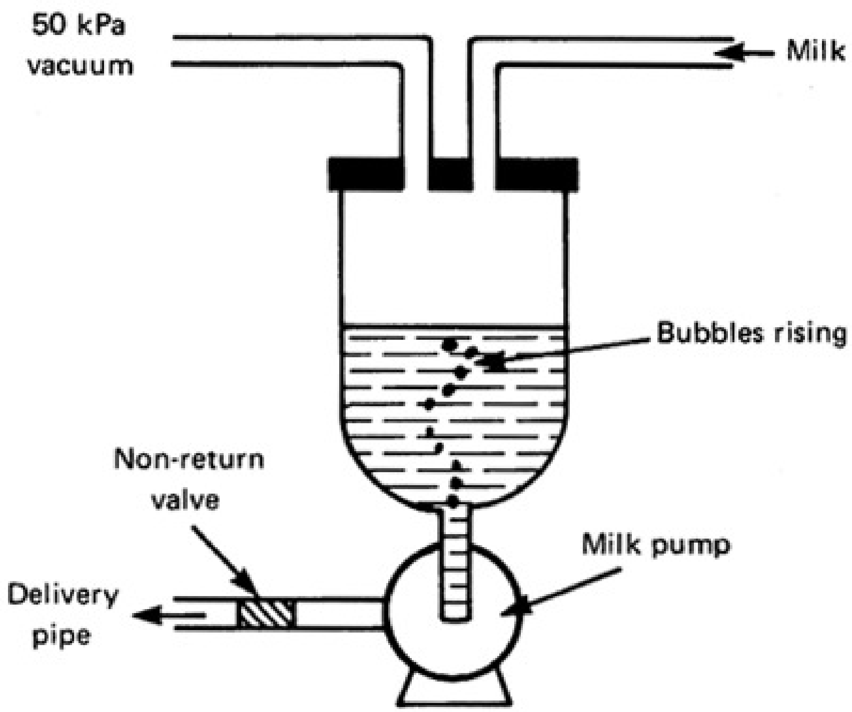
Check that damping rings or rubbers etc are not damaged.

Particular care must be taken when reassembling Servo Regulators. Observe closely during dismantling how rubber diaphragms, pilot valves etc, are fitted, so that they can be assembled correctly.

<u>The vacuum line and vacuum pump interceptor trap should be washed</u> through with hot detergent-hypochlorite solution. Make up a wash solution of detergent in hot water (10–12 litres at 60–70°C) With the addition of hypochlorite (250 ppm). In the case of branched lines, this quantity should be drawn in along each branch. Provision should be made to enable this to be carried out easily by providing at the end of each pipeline a cock or valve with a nipple suitable for attaching a rubber tube to suck the liquid from a bucket into the pipeline. When sucking the solution into the pipeline, allow air to be drawn in at the same time by withdrawing the tube from the solution at frequent intervals. The air liquid mixture will achieve a scrubbing action in the pipeline and be more effective than a solid stream of liquid. Most interceptor vessels are about 18–20 litres capacity and must be emptied after each 12 litres of cleaning solution has been drawn into the plant. After washing the lines the drain cocks must be left open to allow the vacuum system to drain. Before re-installing the interceptor, check the rubber eals and observe if there are any small holes in the base of the interceptor where air leaks can occur. These can cause a carry over of liquid from the interceptor to the detriment of the vacuum pump.

- **carry out manufacturers maintenance instructions for PULSATORS Pneumatic self contained pulsators, if badly worn, can usually be made good by replacing worn components, ie. rubber diaphragms, valve slide and spring. Exchange reconditioned pulsators are available.**

- **check for air leaks at MILK PUMP rubber non-return valve or shaft seals. With water in the receiver jar and under vacuum look for air bubbles in jar. If present dismantle and find cause.**



<u>Pulsator maintenance</u> varies depending on type, (electronic, electro-pneumatic and pneumatic) and whether relay or self contained. Manufacturers instructions should be followed. Filters, air inlet ports and in the case of pneumatic pulsators, the valve and valve slides require cleaning.

A pulsator performs about 6 million operations a year and is therefore subject to considerable wear. A badly worn pulsator can usually be made to operate satisfactorily by replacing the worn components with new parts supplied by the manufacturer e.g. rubber diaphragms, valve slides and springs. It will normally be necessary after two or three years to replace pneumatic pulsators and pneumatic relays. Manufacturers may have an exchange service providing reconditioned pulsators.

MILK PUMPS

The performance of a centrifugal milk pump can be seriously affected, even made inoperative, by air leaks at the rubber seal on the drive shaft or the non-return flap valve fitted in the pump outlet or delivery pipe. Where glass receivers are in use, test for leaks by putting approximately 4 litres of water in the receiver with the milk pump not working. With the receiver vessel under vacuum look for air bubbles rising to the surface from the receiver outlet. If a continuous stream of bubbles is seen dismantle the non-return valve and examine rubber flap for wear and distortion, renew if necessary. If leaks continue replace pump or dismantle and renew shaft seal, inspecting shaft for wear. It will be necessary to replace pump if there are signs of annular grooves on shaft.

Routine replacements

- Renew milking machine liners every six months, or 2,000 cow milkings.
- Replace long milk tubes every year.
- Replace long pulse tubes, rubber elbows and connectors every two years or when damaged.

Yearly

A full test of the milking machine must be carried out once a year by an experienced technician as laid down in the International Standards; ISO 5707 “Milking Machine Installations - Construction and Performance” and ISO 6690 “Milking Machine Installations - Mechanical Tests”.

Carry out any remedial work recommended.

Further Reading

Machine Milking, Technical Bulletin 1. The National Institute for Research in Dairying, Reading, England. Reprinted 1983.

YEARLY

A full test of the milking machine must be carried out once a year by an experienced technician as laid down in the International Standards; ISO 5707 “Milking Machine Installations - Construction and Performance” and ISO 6690 “Milking Machine Installations - Mechanical tests”.

Carry out any remedial work that the tests indicate are required.

RUBBERWARE, PARTICULARLY LINERS, SHOULD BE REPLACED WHENEVER IT BECOMES MISSHAPEN OR DAMAGED. LINER LIFE DEPENDS ON THE NUMBER OF COWS MILKED BUT IT IS SUGGESTED THAT LINERS SHOULD BE RENEWED AT LEAST TWICE A YEAR AND OTHER RUBBER PARTS ANNUALLY

INTERNATIONAL STANDARDS FOR MACHINE MILKING INSTALLATIONS AND TESTING (ISO 5707 and 6690, 1983-02-01)

In recent years the International Standards Organisation (ISO) a world federation of national standards institutes (ISO member bodies) has worked with other organisations for a standardisation of the terms and descriptions of the components used in machine milking and an acceptable performance of milking machine installations. It has drawn on recent research and devised a standard unifying the many national standards that existed. Furthermore a test procedure has been produced which can be used to assess the acceptability of milking machine systems and to check their performance at regular intervals after installation.

The International Standard, 5707, on Milking Machine Installations was prepared jointly with the International Dairy Federation (I.D.F.) and other interested bodies, ie., European Committee of Associations of Manufacturers of Agricultural Machinery (C.E.M.A.) and the International Committee on Recording the Productivity of Milk Animals (I.C.R.P.M.A.). It specifies the minimum performance requirements and certain dimensional requirements for the satisfactory functioning of milking machines. In addition it lists the requirements of materials, construction and installation. ISO Standard No. 6690 on Mechanical tests was produced at the same time with the object of providing test procedures for confirming that an installation meets the minimum requirements of ISO 5707.

The following is a brief outline of items covered by the standards.

ISO STANDARD 5707 - CONSTRUCTION AND PERFORMANCE

Vacuum pumps should be of adequate capacity to meet the operating requirements for both milking and cleaning and to provide a reserve. The reserve capacity is calculated for each milking installation. A formulae is given for calculating this, together with a formulae to calculate the effect of altitude on vacuum pump capacity. The installation of a separate vacuum system is recommended for ancillary vacuum-operated equipment. However, where this is not

provided, an additional allowance for vacuum-operated equipment that does not operate during the static tests should be added to the effective reserve figure. Manufacturers are required to show the air consumption on all components. There are recommendations for the installations of vacuum pumps and exhaust systems. Facilities for measuring vacuum and air flows should be provided.

Vacuum regulators should be capable of controlling the vacuum pump used. They should be marked with the designed working vacuum level and with the air flow capacity at this level. A sensitivity standard has een introduced, together with standards for regulator leakage.

The acceptable drop in vacuum due to friction within the air pipeline (milking vacuum) is stated and recommended diameters of internal pipes are given for various air flow rates.

The interceptor capacity should be at least 15 litres. It should also be provided with an automatic cut-off and drainage facilitie. The inlet to and outlet from the interceptor should be the same diameter as the air pipeline.

A sanitary trap should be fitted to form a connexion between the vacuum system and the receiver vessel.

Requirements for pulsation ratio are closely defined, specifying minimum ‘collapse’ and ‘open’ phases of the pulsation cycle.

Where milking pipeline systems are installed, a specific recommendation has been made for pipeline sizes to ensure that the vacuum drop does not exceed 3 kPa with all units working. The diameter is determined in relation to the total length of the line and the rate of milk and air flows. No risers are permitted.

Where recorder jars are used, the design should be suitable for in-place cleaning and recommendations are made in relation to the height of installation (ie. metres above sea level)

To avoid any unnecessary vacuum drop in the milking system, attachments installed between a cluster and the milking pipeline (eg, recorder jar or bucket) should not cause a vacuum drop of more than 3 kPa at a milk flowrate of 3 kg per minute.

Detailed specifications and minimum internal dimensions are given for flexible tubes, ie, long milk tubes, 12.5 mm; short milk tubes, 8 mm; long pulse tubes, 7 mm except for bucket milking with alternate pulsation which is 6 mm; short pulse tubes, 5 mm and vacuum tubes 10 mm. There are also requirements for teat cup liners, shells and claws.

The standard also requires the installer to provide written instructions for operating and cleaning the equipment and also mechanical details of the system.

<u>The Mechanical Testing Procedures in ISO 6690</u> have been devised to enable static tests of the milking installation to confirm that it meets the requirements contained in ISO 5707.

Briefly this is done by first observing that the correct pipe sizes and method of installing and construction are used. Then with the mouthpiece of the liners sealed with bungs, the vacuum pump running and all components operating, confirm that the vacuum pump capacity is sufficient to give the effective reserve required to the size of installation. This is done by measuring the air flow and vacuum level with an air flow meter and vacuum gauge. Next a check is made that the regulated/controlled vacuum level is correct and stable. Then with a continuous vacuum recording instrument connected to the pulsation chamber of a teat cup assembly, record the pulsation characteristics and confirm that the results for each unit is satisfactory.

These results should be entered on a standard form and compared with the original test results. The installer of the installation should carry out the commissioning test with the records left on the farm for future comparisons.

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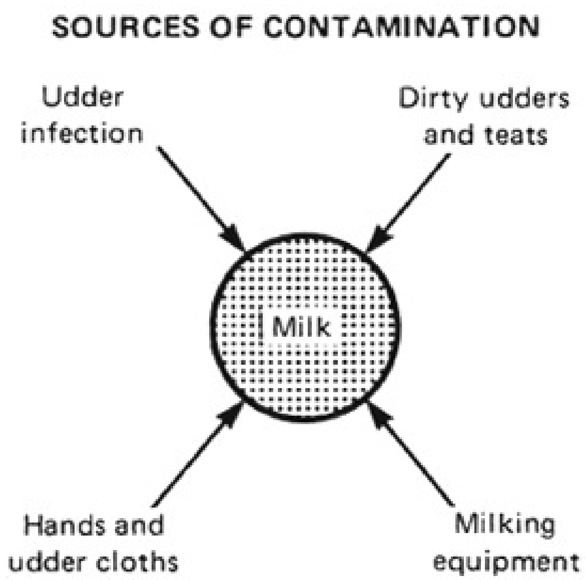
3. MILK HYGIENE

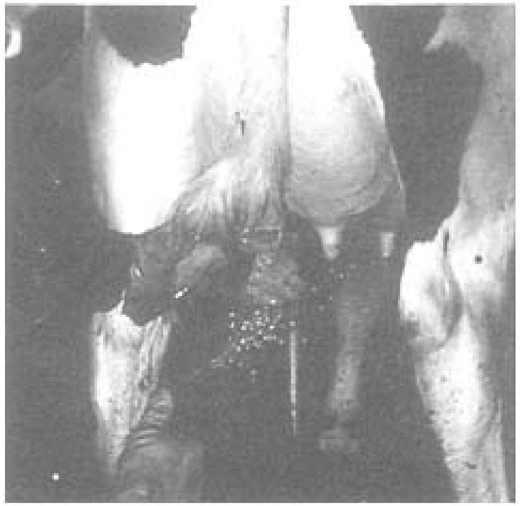
Milk hygiene

MILK IS STERILE when secreted into an uninfected udder. Contamination occurs during and after milking. Exclude milk from clinical mastitis cases to avoid high bacterial counts. Use mastitis control routines at each milking to reduce the proportion of infected cows and clinical mastitis cases.



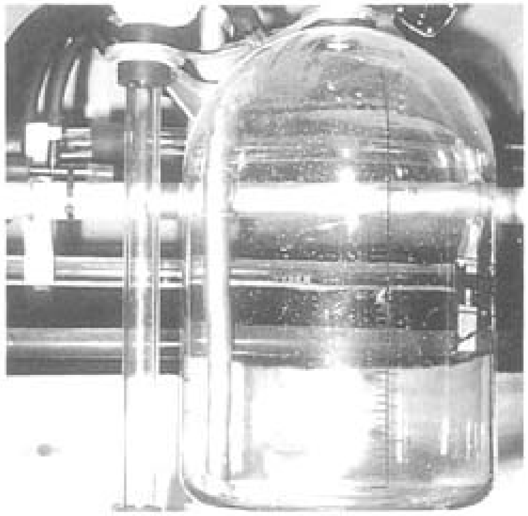
AVOID CONTAMINATION from dirty udders

and teats by good cow housing and grazing management. Wash off visible dirt from udders and teats prior to applying the teat-cups.



If udder washing is necessary, then drying afterwards is essential. Individual paper towels for both washing and drying are preferable to udder cloths.

CLEAN AND DISINFECT milking and ancillary equipment after use, paying particular attention to milk contact surfaces which are a main source of contamination.



MILK HYGIENE

The milk secreted into an uninfected cow's udder is sterile. Invariably it becomes contaminated during milking, cooling and storage, and milk is an excellent medium for bacteria, yeasts and moulds that are the common contaminants. Their rapid growth, particularly at high ambient temperatures can cause marked deterioration, spoiling the milk for liquid consumption or manufacture into dairy products. This can be avoided by adopting the simple, basic rules of clean milk production.

Udder infection

The essential requirements are to maintain udders free from infection (eg. mastitis); manage cows so that their udders and teats are clean; milk them in such a way that minimises bacterial contamination; store the milk in clean containers and, wherever possible, at temperatures which discourage bacterial growth until collected. Simple and low-cost husbandry practises

enable milk to be produced with a bacterial count of less than 50,000 per ml. The golden rule of clean milk production is that prevention is better than cure.

It is impossible to prevent mastitis infection entirely but by adopting practical routines it can be kept at low levels. Most mastitis is subclinical and although not readily detected by the stockman, it will not normally raise the bacterial count of herd milk above 50,000 per ml. Once the clinical stage is reached, the count may increase to several millions/ml and one infected quarter may result in the milk from the whole herd being unacceptable. It is important to detect clinical cases and exclude their milk from the bulk.

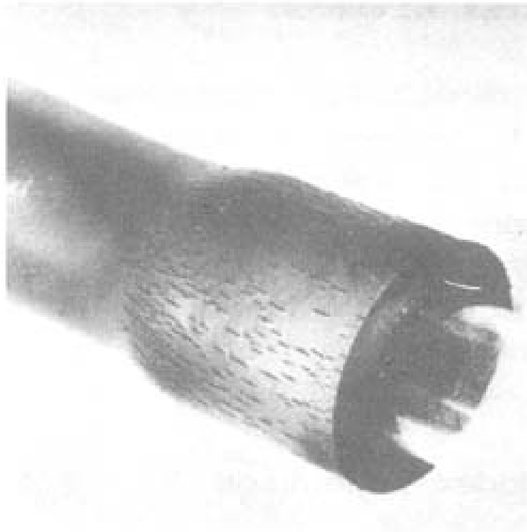
Other sources of contamination

Under normal grazing conditions, cows' udders will appear clean and therefore washing and drying will be unnecessary. Otherwise, any visible dirt must be removed using clean, running water, individual paper towels or cloths in clean water to which a disinfectant has been added (eg. sodium hypochlorite at 300 ppm). If udder cloths are used, provide a clean cloth for each cow. After each milking wash and disinfect them and hang up to dry. Disposable paper towels are preferable and more effective for drying after washing. When cows are housed or graze in heavily stocked paddocks, external udder surfaces are usually grossly contaminated with bacteria even when they appear visibly clean, therefore routine udder preparation procedures should be followed. Whenever udders are washed they should be dried.

Foremilking has little affect on the total bacterial count of the milk but is an effective way of detecting clinical symptoms of mastitis. Filtering or straining the milk removes visible dirt but not the bacteria in the milk because they pass through the filter. Aerial contamination of milk by bacteria is insignificant under normal production conditions.

The milk contact surfaces of milking and cooling equipment are a main source of milk contamination and frequently the principal cause of consistently high bacterial counts. Simple, inexpensive cleaning and disinfecting routines can virtually eliminate this source of contamination.

MILKING EQUIPMENT must have smooth milk contact surfaces with minimal joints and crevices. Renew rubber components at regular intervals.



WATER FOR DAIRY USE must be either an approved, piped supply or chlorinated (50 ppm) before use. In hard water areas, milking and ancillary equipment must be de-scaled periodically.

DETERGENTS are necessary to clean

milking and ancillary equipment effectively before disinfection. Effectiveness is increased with solution temperature, concentration and time of application.

Cleaning milk production equipment

It is virtually impossible with practical cleaning systems to remove all milk residues and deposits from the milk contact surfaces of milking equipment. Except in very cold, dry weather, bacteria will multiply on these surfaces during the interval between milkings, so that high numbers (eg 106 per m2) can be present on visually clean equipment. A proven cleaning and disinfectant routine is required so that with the minimum of effort and expense, the equipment will have low bacterial counts as well as being visually clean.

The essential requirements are, to use milking equipment with smooth milk contact surfaces with minimal joints and crevices, an uncontaminated water supply, detergents to remove deposits and milk residues and a method of disinfection to kill bacteria.

Water supplies

Unless an approved piped supply is available it must be assumed that water is contaminated and therefore hypochlorite must be added at the rate of 50 ppm to the cleaning water. Hard

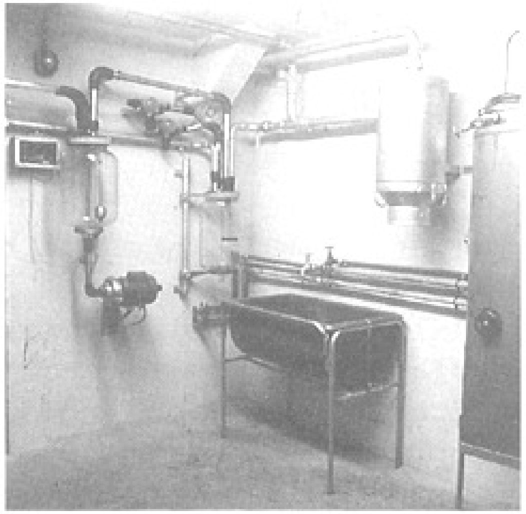
water (ie. high levels of dissolved calcium and other salts) will cause surface deposits on equipment and reduce cleaning effectiveness. In such cases, it is necessary to use de-scaling acids such as sulphamic or phosphoric, periodically.

Detergents and disinfectants

Detergents increase the 'wetting' potential over the surfaces to be cleaned, displace milk deposits, dissolve milk protein, emulsify the fat and aid the removal of dirt. Detergent effectiveness is usually increased with increasing water temperature, and by using the correct concentration and time of application. Detergents contain inorganic alkalis (eg. sodium carbonate and silicates and tri-sodium phosphate), surface-active agents (or wetting agents), sequestering (water-softening) agents (eg. polyphosphates) and acids for de-scaling. Many proprietary, purpose-made detergents are usually available, but otherwise, an inexpensive mixture can be made to give a concentration in solution of 0.25% sodium carbonate (washing soda) and 0.05% polyphosphate (Calgon). Disinfectants are required to destroy the bacteria remaining and subsequently multiplying on the cleaned surfaces. The alternatives are either heat applied as hot water or chemicals. Heat penetrates deposits and crevices and kills bacteria, providing that correct temperatures are maintained during the process of disinfection. The effectiveness of chemicals is increased with temperature but even so, they do not have the same penetration potential as heat and they will not effectively disinfect milk contact surfaces which are difficult to clean.

DISINFECT milk contact surfaces with either hot water (≥85°C initial temperature) alone or with a chemical disinfectant.

PROVIDE A DAIRY or suitable place for cleaning and disinfecting, draining and storing milking and ancillary equipment which is not cleaned and disinfected in-situ.

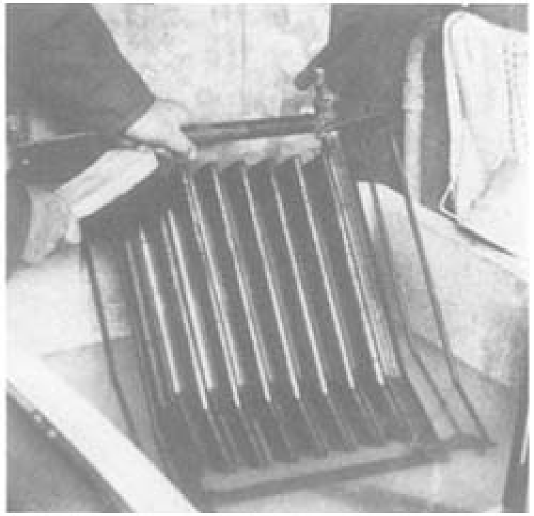


When hot water alone is used, it is best to begin the routine with water at not less than 85°C, so that a temperature of at least 77°C can be maintained for at least 2 minutes. Many chemicals are suitable as disinfectants, some of them combined with detergents (ie. detergent-sterilisers). Use only those which are approved, avoiding particularly those which can taint milk (eg. phenolic disinfectants). <u>Always follow the manufacturers instructions.</u> Sodium hypochlorite is an inexpensive example of an approved disinfectant suitable for most dairy purposes. Sodium

hydroxide (caustic soda) can also be very effective at concentrations of 3%–5% at ambient temperatures, providing adequate contact time is given with the surfaces to be cleaned and disinfected.

<u>Dairy disinfectants are sold as concentrates and in this form are often corrosive and damaging to the skin and eyes. They should always be so labelled, handled with care and stored out of reach of children. Disinfectants should not be mixed unless specific instructions are given and disinfectant powders must be kept dry. If any concentrated detergent and/or disinfectant comes in contact with the skin or eyes the affected area should be washed immediately with copious amounts of clean water. If acids are used they must always be added to the water NOT vice versa.</u>

CLEAN AND DISINFECT the ancillary equipment such as coolers, foremilk cups and udder cloths effectively using hot detergent/disinfectant solution.



DRAIN AND STORE all the milking and ancillary equipment in a clean place such as the dairy of the milking premises.

Milking premises

The milking premises should have a dairy or suitable place equipped with a piped hot and cold water supply, a washtrough, brushes, a work surface, storage racks and cupboards and, if necessary, a vacuum pipeline connection. In addition, it is advisable to have a dairy thermometer (0°C - 100°C), rubber gloves and goggles for use when handling chemicals.

Daily routines

Daily routines for cleaning and disinfecting vary with the size and complexity of the milking installation but will include methods of removing dirt and milk from the equipment followed by disinfection. For hand milking, bucket and direct-to-can milking machines, basic manual methods of cleaning and sterilizing are adequate and effective. For pipeline milking machines in-situ (in-place) systems are necessary.

Milk can become grossly contaminated from bacteria on ancillary equipment which must also be cleaned and disinfected effectively. Coolers, either the corrugated surface or the turbine in-

can, can best be cleaned and disinfected manually and stored in the dairy to drain. Refrigerated bulk milk tanks can be cleaned either manually using cold or warm detergent/disinfectant solutions, or for the larger tanks, by automatic, programmed equipment. In either case, a cold water chlorinated (50 ppm) rinse preceeds and follows the washing solution. Foremilk cups can be a potent source of bacterial contamination and need to be cleaned and disinfected after each milking. They should then be stored in the dairy to drain.

It is important with any method of cleaning that the equipment is drained as soon as possible after washing for storage between milkings. Bacteria will not multiply in dry conditions but water lodged in milking equipment will, in suitable temperatures, provide conditions for massive bacterial multiplication. Equipment with poor milk contact surfaces, crevices and large number of joints, remaining wet between milkings in ambient temperatures above 20°C, should receive a disinfectant rinse (50 ppm available chlorine) before milking begins.

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4. MASTITS CONTROL

MASTITIS

Mastitis is an inflammation of one or more quarters of the udder usually caused by bacterial infection.

Several types of bacteria cause distinctly different mastitis infections.

Most mastitis persists as subclinical infections and is not detected by the milker, only occasionally are there clinical signs with clots in the milk and inflamed quarters.

Antibiotic infusions into the udder nearly always cure the clinical disease but may not eliminate the bacterial infection.

Mastitis reduces milk yields, increases the cost of production and makes milk less valuable for liquid consumption and manufacture.

The pattern of infection in dairy cows.

MASTITIS CONTROL

Mastitis

Mastitis is an inflammation of the udder and is common in dairy herds causing important economic losses. It cannot be eradicated but can be reduced to low levels by good management of dairy cows.

Of the several causes of mastitis only microbial infection is important. Although bacteria, fungi, yeasts and possibly virus can cause udder infection the main agents are bacteria. The most

common pathogens are Staphylococcus aureus, Streptococcus agalactiae, Str. dysgalactiae, Str. uberis and Escherichia coli though other pathogens can cause occasional herd outbreaks. Mastitis occurs when the teats of cows are exposed to pathogens which penetrate the teat duct and establish an infection in one or more quarters within the udder. The course of an infection varies, most commonly it persists for weeks or months in a mild form which is not detected by the stockman (ie. subclinical mastitis). With some pathogens, typically E coli, the infection is frequently more acute and there is a general endotoxaemia with raised body temperature, loss of appetite and the cow may die unless supportive therapy is given. When clinical mastitis occurs the effective therapy is a course of antibiotic infusions through the teat duct. These nearly always remedy the clinical disease and often eliminate the bacterial infection. Infections may spontaneously recover but most persist to be eliminated eventually by antibiotic therapy or when the cow is culled. The susceptibility of cows varies considerably and new infections are most common in older cows in early lactation, at the start of the dry period and when the management is poor.

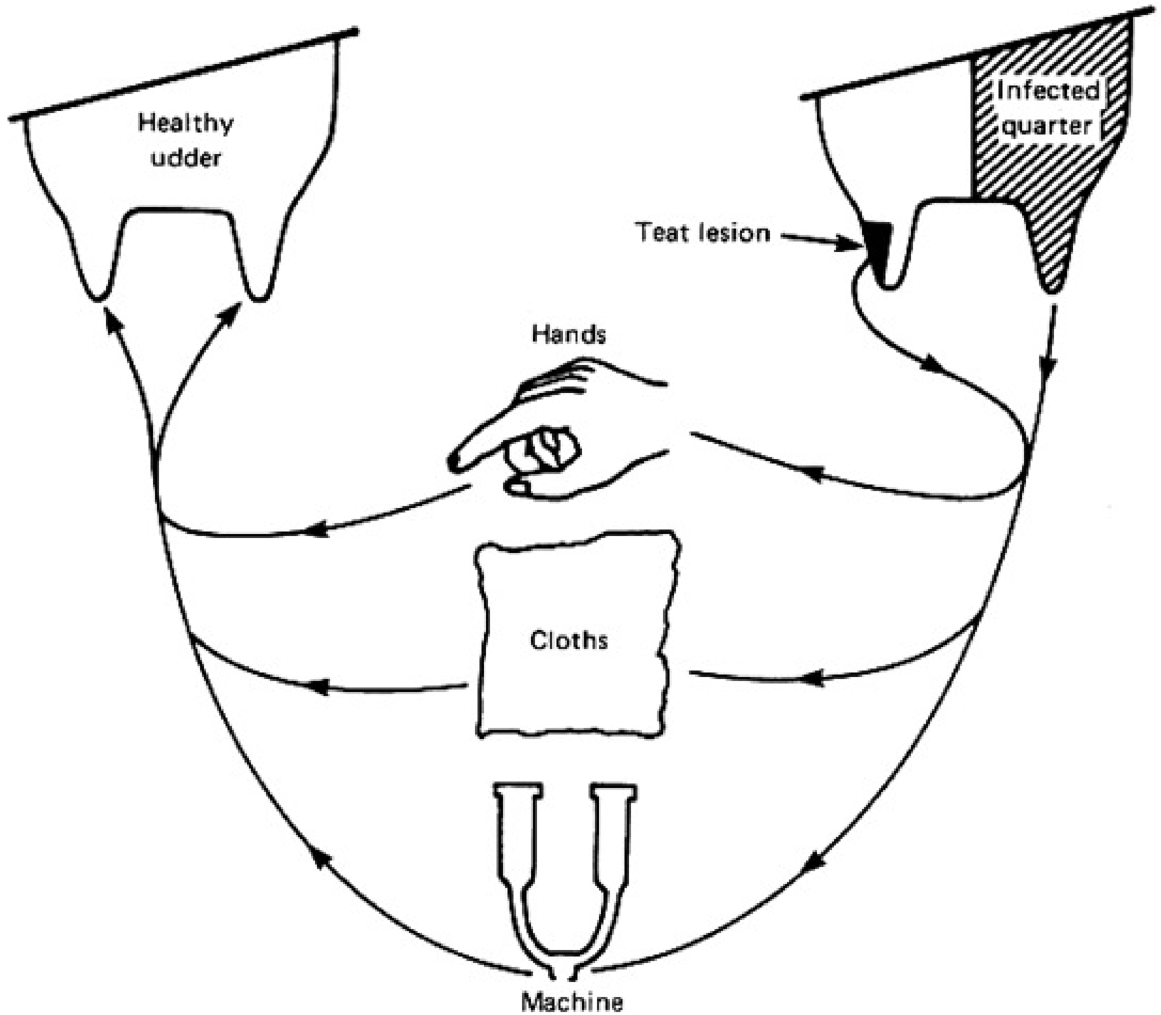
Mastitis causes direct economic losses to farmers in several ways. Milk yields are reduced, milk that is abnormal or contaminated with antibiotics is unsaleable, there are veterinary and antibiotic costs, a higher culling rate and occasional fatalities. The milk processing industry also incurs losses because of problems that result from antibiotic in milk, and the reduced chemical and bacterial quality of mastitic milk.

INFECTIOUS MASTITIS

Mastitis microorganisms, usually bacteria, originate in various sites on the cow. They multiply in various ways and are spread from cow to cow.

Most common types of mastitis bacteria originate in the udders of infected cows and in sores

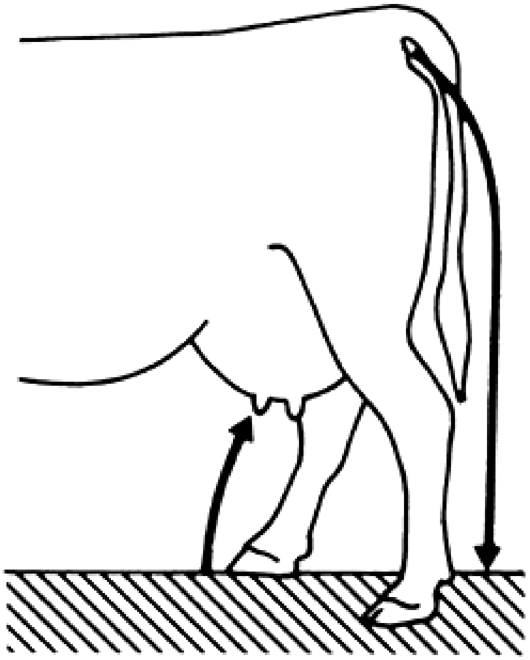
on tests. These pathogens multiply in teat sores and are spread during milking.



Spread of mastitis bacteria at milking from infected quarters and teat lesions

Other serious forms of mastitis are caused by bacteria which come from other sites on the cow (eg. in dung). These bacteria multiply in bedding materials.

Mastitis inflammation can be detected by simple tests on cows milk (eg. CMT test) but the causative bacteria can be detected only by laboratory tests.



Spread of the bacteria from dung etc that multiply in bedding materials

Infectious mastitis

The several microbial diseases of the udder that are collectively known as mastitis are distinctly different. The pathogens can arise from different primary sites, they multiply in different environments and therefore the timing of the exposure of the cow to the bacteria will vary. Subsequently the acuteness and persistency of the infections differ and also the probability of cure when therapy is given.

The commonest forms of mastitis in most countries are caused by S. aureus and Str. agalactiae. The primary sites of these is the milk of infected quarters and therefore they are spread mainly at milking, either during udder preparation or on hands and milking machines. These pathogens can colonise and multiply in teat sores and in teat ducts and this greatly

increases the degree of exposure of the teats to bacteria. They usually cause chronic infections which persist in the subclinical form and occasionally become clinical when abnormal milk can be detected. Systemic infection with loss of appetite and raised body temperature is infrequent. When suitable antibiotic preparations are infused into the udder the clinical mastitis nearly always subsides and most Str. agalactiae infections are cured but with staphylococcal infections the cure rate is poor and most persist.

Infections caused by Str. uberis and E. coli are often called ‘environmental’. The main primary sites of the pathogens are bovine, but not from within the udder. These do not normally colonise teat skin and the multiplication occurs in organic bedding materials (eg. straws and sawdust). These types of infection are most common in housed cattle in early lactation and whilst they can cause persisting subclinical mastitis the more typical from is clinical mastitis soon after the onset of the infection, and with coliform mastitis the endotoxaemia causes raised body temperature and marked reductions in milk production. Str. uberis infections usually respond to therapy but with E. coli infections it is important to give supportive treatment to overcome the endotoxaemia and if this is successful spontaneous recovery usually follows.

Str. dysgalactiae is similar to Str. agalactiae and S. aureus in that it can readily colonise and multiply in teat lesions but the main primary site is not the milk of infected quarters, but other bovine sites. The course of the infection is not dissimilar to Str. agalactiae and infections respond readily to antibiotic therapy.

Many other microorganisms can cause mastitis. These less common forms are not usually important but pseudomonads and Mycoplasma bovis does cause serious problems in a few herds.

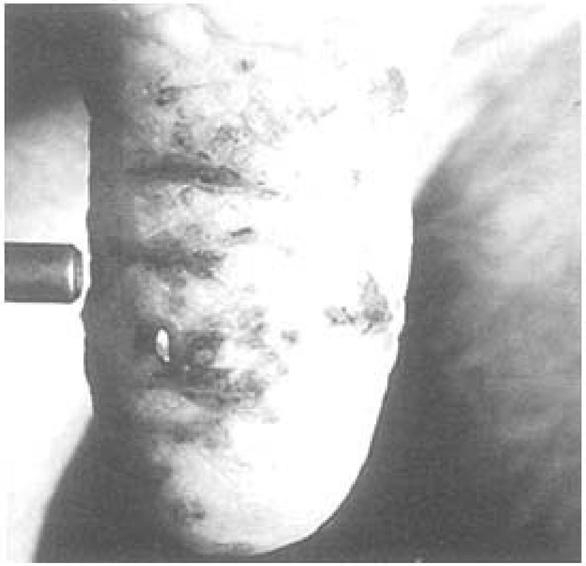
Although the pathology of the various types of infection show distinct differences the causes of infection can be diagnosed with certainty only by bacteriological tests made on aseptically taken quarter milk samples.

CAUSES OF MASTITIS

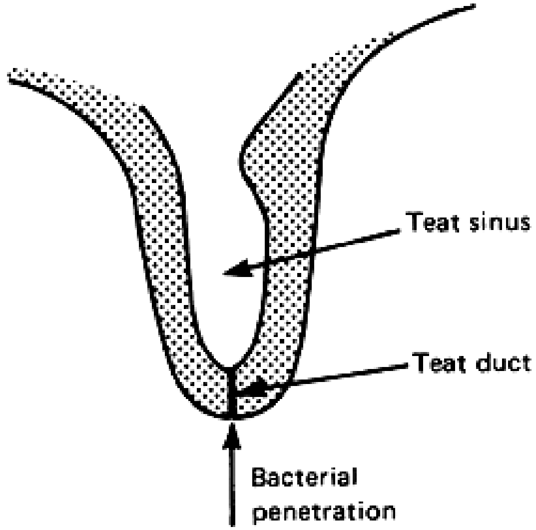
An udder quarter becomes infected when

- **the teats are exposed to pathogens**
- **the pathogens penetrate the teat duct**
- **the infection is established within the udder**

Bacterial exposure is greatly increased when bacteria multiply in teat sores and ducts or in grossly contaminated bedding. The former can be prevented by post milking teat disinfection, the latter by providing clean bedding.



Penetration of the teat duct can occur either during milking or between milking. It is most common with damaged teats and with poorly designed milking equipment which gives 'reverse flow' of milk during milking.



THE COW HAS SEVERAL NATURAL DEFENCES AGAINST INFECTION, THE MOST IMPORTANT ONE IS THE HEALTHY TEAT DUCT WHICH PREVENTS BACTERIAL PENETRATION. The defence mechanisms within the udder act mainly to reduce the severity of infections but can eliminate some types of infection.

Many factors influence the frequency of mastitis infection and management is particularly important. New infection is most common at drying off, at calving, in older cows and in poorly managed cows.

Causes of mastitis

For an intramammary infection to occur it is necessary for:

- **the teat skin to be contaminated with pathogens**
- **the pathogens to penetrate the teat duct**
- **the infection to be established in the sinuses, ducts or tissues of the udder**

Exposure to Pathogens

All dairy cows are continously exposed to pathogens that can cause mastitis but new infection is normally infrequent. This is because the exposure to pathogens is usually small. The number of pathogens in the milk of infected quarters will vary from less than 1000 to many millions per ml of milk but it is usually less than 10,000 per ml and further diluted by the milk from the majority of uninfected quarters. The number of pathogens on clean pasture will be extremely small. The exposure of cows teats to S. aureus, Str. agalactiae and Str. dysgalactiae will be greatly increased when teat sores and lesions on teat ducts are colonised by these mastitis pathogens or when cows lie on contaminated bedding or corrals. Occasionally the exposure will be increased from improperly cleaned milking equipment or through udder washing with contaminated water. This can be avoided by adopting simple methods of cleaning equipment (see page 29).

The most effective way of reducing the exposure to S. aureus, Str. agalactiae and Str. dysgalactiae is by dipping or spraying the teats in disinfectant immediately after milking. A number of disinfectant products are available and good results are obtained with hypochlorite, iodophor and chlorhexidine. Teat disinfection greatly reduces residual contamination and more importantly encourages healing of teat sores and lesions and also prevents the growth of pathogens in teat ducts (ie. colonisation). Other practices such as udder washing with disinfectant, rinsing milking equipment after each cow is milked (eg. back flushing) will also reduce exposure but their effects are smaller than teat dipping because they do not influence the colonisation of teat sores and ducts. To maintain low levels of exposure it is most important to maintain healthy teat skin and avoid sores, chaps and any form of teat damage. To maintain good teat condition emolients or salves (eg. glycerol) can be added to most teat dips but not to hypochlorite.

While soil and fresh bedding materials are usually relatively free from mastitis pathogens they can develop a very large pathogen population (>106/gm) within a few days given the optimum conditions of moisture and temperature. Inevitably bedding becomes moist and contaminated with faeces and given sufficient warmth the growth of E. coli and Str. uberis is rapid causing outbreaks of mastitis. This can be prevented by avoiding using muddy corrals and by keeping cows on clean pasture. When cattle are housed on straw or sawdust in yards or in cubicles (freestalls), it should be replenished frequently, preferably daily. Straw yards should be cleaned completely if outbreaks of clinical mastitis occur. For cows kept in cubicles sand can be used successfully as a non-organic bedding material in which coliforms and Str. uberis do not readily multiply.

Penetration of the Teat Duct

The healthy teat duct (streak canal) is extremely effective in preventing the passage of pathogens into the udder and it is the cows most natural barrier against mastitis infections. It not only acts as a physical barrier against penetration but the lining of the duct also contains secretions that inhibit bacterial growth. Pathogen penetration can occur during milking, in the intervals between milking and even when cows are not lactating. If pathogens penetrate during milking they may be flushed out otherwise infection usually occurs. It is most important to recognise that even when very small numbers of pathogens (eg. less than 20) penetrate the duct infection usually occurs. Apart from the increased rate of penetration that occurs with high rates of exposure there are other factors in cattle management that are important. These occur with faulty machine milking and also if milkers insert contaminated objects (eg. dirty treatment syringes) through the teat duct.

Under certain milking machine conditions there are considerable vacuum fluctuations in the teat cup liner below the teat. In the resulting turbulence the milk which is normally flowing away

from the teats returns to the teat through the short milk tubes (ie. reverse flow or impacts). These impacts can have sufficient force that the pathogens carried in the milk penetrate into or through the teat duct causing infection. These infections can be reduced by using a milking machine fitted with liners that do not slip during milking, that have adequate diameter short milk tubes and an effective airbleed in the clawpiece. Even better protection is achieved by using liners fitted with 'shields' or milking with 'non-return valves' in the milking machine cluster (see page 16).

Inserting instruments through the teat duct should be avoided but when necessary (eg. for therapy) the teat end should be scrubbed with disinfectant for 15 seconds before insertion and the instrument must be sterile. If in doubt about sterility the instrument should be placed in boiling water for at least 30 seconds, but if this is impractical it should be scrubbed in surgical spirit (70% ethanol).

Establishment of Infection

A number of antimicrobial systems occur in the bovine udder and milk but they appear to be relatively ineffective in preventing infections though they are important in reducing the severity of infections and to a lesser degree in eliminating infections. The hosts defences are partly cellular (leucocytes) and immune defences and in addition there are non-specific defences provided by complex biochemical systems including enzymes and other constituents of milk. Although most types of infection tend to persist for months if untreated the cellular defences will eliminate most E. coli infections providing the cows cellular response to infection is rapid.

This brief description of the prime importance of pathogen exposure, duct penetration and the establishment of infection deals only with the main aspects that are important in considering mastitis control. The interactions are more complex and not fully understood. There are other

physiological and environmental factors which are or appear to be important in particular herds. These include nutrition, heat stress and factors such as age of cow and stage of lactation.

ELIMINATION OF INFECTIONS

- most mastitis persists undetected as subclinical infections

- examine the milk and udder at each milking for clinical mastitis and give treatment under veterinary supervision

- treatment is by infusions of antibiotic preparations through the teat duct. Most clinical mastitis is cured but infections may not be eliminated.

- treatment with special products at drying off gives higher rates of elimination and prevents new dry period infections.

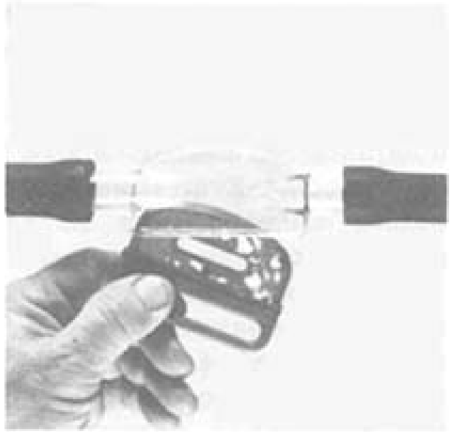
- always use single dose tubes, not multiple dose bottles which can become contaminated

- always scrub teat end with disinfectant for at least 10 seconds before infusion

- after treatment do not add antibiotic contaminated milk into bulk supply until recommended antibiotic retention period has elapsed.

- some severe cases of mastitis may not respond to infusions of antibiotic.
If cows have high temperatures and do not eat call for veterinary assistance

- cows that have repeated cases of clinical mastitis should be culled.



Elimination of infection

Apart from E. coli infections most persist if untreated until eventually there is spontaneous recovery or the cow is culled. This persistance of infection for weeks, months and years with staphylococcal infections is an important characteristic of mastitis which must be taken into account in devising a disease control.

Because spontaneous recovery occurs infrequently and there is no proven way of increasing it the introduction of antibiotic therapy was a major advance in controlling bovine mastitis. Infusing antibiotics via the teat duct into the udder is a simple way of overcoming nearly all clinical mastitis and of eliminating many infections. Many antimicrobial drugs are used in formulating products for mastitis therapy (eg. penicillin including the semisynthetics, streptomycin, aureomycin). The effectiveness of the drug will depend partly on the sensitivity of the pathogen treated to the drug used and also to the way the drug is formulated. This influences the absorption, distribution, metabolism and excretion of the drugs from the milk. No antimicrobial drug is ideal for all conditions and mixtures are used to be effective against a range of pathogens (ie. 'broad spectrum') for use in lactating and dry cows. Nearly all therapy is given without prior knowledge of the causative pathogen. Under these conditions treating quarters exhibiting clinical mastitis with basic standard products gives a bacteriological elimination of 75–90% of streptococcal and about 30% of staphylococcal infections. The cure rates of mycoplasma and pseudomonad infections are lower. If the treatments are given after the final milking of lactation (ie. dry cow therapy) using formulations designed for this purpose the cure rates are improved and are about 50% for staphylococcal infections. The rates of elimination of staphylococcal infections varies considerably between herds and are lower in cows with more than one infected quarter and those with more severe clinical mastitis.

Antibiotic therapy is usually given as infusions of solutions through the teat duct but this

should be done only after careful cleaning of the teat orifice with a disinfectant swab. To avoid infusing contaminated antibiotic, use only factory made disposable syringes. A course of therapy is often 2 or 3 infusions at 24 hour intervals, rejecting the milk from the cow for 2 or more days after the last infusion to avoid antibiotic contamination of the bulk milk. Although nearly all cases of clinical mastitis respond quickly it may take several days before the milk becomes normal. Treatment, the choice of antibiotic and the milk reject time should be on veterinary advice and when there are severe persistent infections systemic administration of antibiotic may also be used to overcome the endotoxaemia.

Many infections are eliminated by culling cows and this can be increased by the sale of cows with persistant clinical mastitis.

PRINCIPLES OF MASTITIS CONTROL

- mastitis cannot be eradicated nor controlled by vaccination or the use of antibiotics alone but it can be reduced to low levels by good cattle management and a planned use of antibiotic treatment

- because mastitis occurs in all herds and causes economic losses in most, the control routine is a continuous operation that must be economic and fit easily into a milking routine.

- mastitis control is based on sound management to prevent new infection. This is done primarily by REDUCING THE EXPOSURE OF THE UDDER TO MASTITIS

PATHOGENS

- not all new infections can be prevented and a control routine MUST INCLUDE METHODS FOR ELIMINATING INFECTION either when they are detected with clinical mastitis or when cows dry off at the end of lactation

Principles of mastitis control

Mastitis cannot be eradicated but can be reduced to low levels by adopting simple economic management routines that relate to the patterns of infection. Currently it is not possible to base a control on vaccination and although cows susceptibilities are largely inherent there are major practical limitations to control through breeding, and progress would be slow. Therapy is invaluable to contain the problem but cannot be the basis of a control which must depend on preventing new infections. In practice the key to control is good cattle management particularly steps to reduce exposure to pathogens and also the planned use of antibiotic therapy. Because control depends on management the steps must be simple and economic and fit easily into a milking routine.

There are three main patterns of infectious mastitis.

The first is the most common and is caused by Streptococcus agalactiae, Staph. aureus and Str. dysgalactiae. These infections usually persist as subclinical infections and this persistance is important. Even if the rate of new infection is considerably reduced the proportion of infected quarters will decline slowly over several years, unless the duration of infection is also reduced. In addition to general good management including sound milking methods, teat disinfection (ie. dipping or spraying) is particularly useful to prevent these infections, by

reducing exposure to pathogens. To reduce the persistance of infection the key step is dry cow therapy.

The second type of infection occurs mainly in housed or closely corralled cattle and is typified by acute clinical mastitis in early lactation. The main pathogens are Str. uberis and E. coli and their epidemiology is such that they are not controlled by teat disinfection (see above). Drying off therapy is useful in preventing Str. uberis infections that commonly occur early in the dry period but it will not reduce the Str. uberis and E. coliform infections occurring at, and soon after, calving. Control depends primarily on reducing the exposure to pathogens by moving cattle regularly to clean corrals or providing clean bedding, preferably daily.

The third type of infection occurs in non-lactating cows. These are common in the early part of the dry period particularly with Str. uberis and most persist causing clinical mastitis in the following lactation. Another form common in N. Europe occurs later in the dry period and is caused by a complex infection with Corynebacterium pyogenes, Peptococcus indolicus and streptococci. This is ‘summer’ or ‘heifer’ mastitis and its aetiology appears to require exposure to pathogens carried by a species of fly. Control is achieved by drying off therapy and fly control.

It is important to recognise that because most mastitis is subclinical and unseen control depends primarily on adopting sound management routines for the whole herd. It cannot be achieved by using laboratory tests to identify individual infected cows and taking special action with these animals. Tests are useful to alert farmers to the extent of the problem but they rarely indicate steps additional to those that should be in the daily routine.

In a concise monograph it is impossible to cover the causes of all types of mastitis. Infrequently a herd mastitis outbreak will occur with an unusual pathogen even when the

farmer adopts good control routines. The solution of this type of problem does require investigation by a veterinary diagnostic laboratory in order to discover the source of pathogen and the aetiology.

CONTROL METHOD

- adopt sound methods of feeding, housing, milking and managing cattle
- adopt good general hygiene including cleaning of milking machines
- dip or spray teats of all cows in disinfectant after each milking
- renew the bedding materials frequently, preferable daily and do not keep cows in dirty paddocks
- avoid teat damage and use emolients in teat dip to encourage healing of teat sores
- use a milking machine that conforms to international standards, that prevents ‘reverse flow’ or the ‘impact’ of milk droplets during milking
- detect clinical mastitis and treat with antibiotic preparation under veterinary supervision
- give antibiotic treatment to cows at drying

off
- adopt good fly control for dry cows

- KEEP RECORDS and cull cows with repeated clinical mastitis

Control methods

The following routine will reduce the proportion of infected cows and clinical mastitis by at least 70% if used regularly at each milking. Mastitis caused by Str. agalactiae will be reduced to very low levels and is frequently eradicated.

1. **Adopt good cow management practices as the essential basis for a mastitis control routine (eg. feeding, housing, hygiene). Mastitis is unlikely to be controlled with neglected, underfed cows kept under stress in dirty conditions.**

2. **Reduce exposure to pathogens**

   - **Clean thoroughly all equipment used when milking (see page 29)**
   - **DO NOT HOUSE OR CORRAL CATTLE UNDER DIRTY CONDITIONS, preferably CHANGE ORGANIC BEDDING MATERIALS DAILY or use sand for bedding**
   - **Wash dirty udders before milking with clean running water preferably with the hand, a disposable paper towel or a disinfected cloth and dry thoroughly. Do not wash with contaminated cloths and water**
   - **DIP OR SPRAY ALL TEATS AFTER MILKING WITH DISINFECTANT TEAT DIP (eg. hypochlorite, iodophor, chlorhexidine)**
   - **Adopt practices that prevent the occurrence of teat lesions (sores, chaps and teat damage). If they occur use a teat dip or spray containing a emolient.**
   - **If practical milk clinically affected cows last**

- **Additional benefits can be obtained by disinfecting hands before milking each cow, using individual paper udder cloths, dipping teat cups in disinfectant before each cow is milked, and 'back flushing'. These reduce bacterial exposure but their effects are secondary to those described above**

3. **Reduce the chances of pathogens penetrating the teat duct by**

- **avoiding teat injury or fly attack**
- **using a milking machine that is correctly tested, and maintained**
- **using a milking machine modified to prevent 'reverse flow' and 'impacts'**

- **minimise the effects of vacuum fluctuations by avoiding 'linerslip', fitting 'shields' or 'non-return valves' into short milk tubes or liners.**

4. **Reduce the duration of infections by**

- **detecting clinical mastitis by examining foremilk or fitting 'mastitis detectors' into the long milk tubes**
- **giving intramammary infusions of antibiotics under veterinary supervision to clinically affected cows and KEEP A RECORD**
- **TREATING COWS AT DRYING OFF with infusions of antibiotics recommended by a veterinarian**

- **CULL COWS WITH REPEATED CLINICAL MASTITIS.**

5. **Reduce mastitis in nonlactating growing cattle or cows in the dry period**

- **Avoid using low lying grazing land and damp wooded areas where flies are common. Move cattle from pastures known to give problems with mastitis**
- **Adopt good fly control measures**
- **TREAT COWS AT DRYING OFF with antibiotics recommended by veterinarian. All cows should be treated, alternatively treat cows that have previously shown signs of infection**

NOTE THE REDUCTION IN INFECTION IS NOT IMMEDIATE BUT LEVELS FALL BY ABOUT 50% IN ONE YEAR AND CONTINUE TO FALL IN SUCCESSIVE YEARS

Mastitis awareness and the organisation of mastitis control

ORGANISATION

World experience indicates that if farmers are to control mastitis successfully they require some technical and laboratory assistance. This can be provided by government agencies, cooperatives or the milk collecting dairies. The support should:

- **provide an extension service (veterinary, animal husbandry and milking machine technology) to ensure that farmers receive the correct information on the best routines to follow for their environment**
- **report regularly to farmers (eg. monthly) giving the results of appropriate tests made on herd bulk milk to indicate the progess made in reducing mastitis**
- **ensure that good milking equipment, disinfectants and antibiotics are available**
- **investigate the causes of failure in herds <u>adopting the recommendations</u> but not making progress**

Although laboratory support is essential it is important to recognise that mastitis is widespread

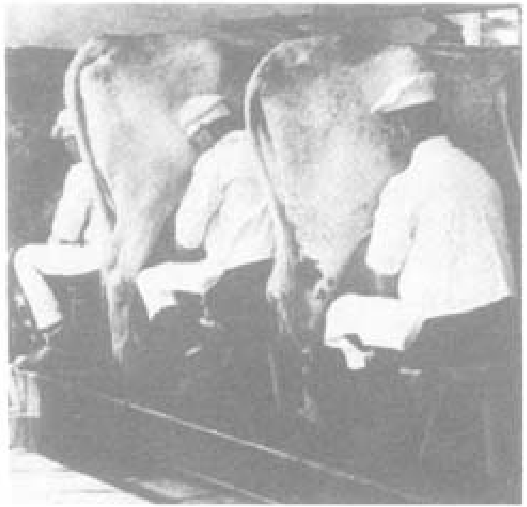
and for successful control in a national herd or the herds in a cooperative it is necessary that most, preferably all, the herds carry out the routine. A control that concentrates on improving the worst 10 to 20% of herds will have little effect on the total problem of mastitis. EFFECTIVE MASTITIS CONTROL DEPENDS ON FARMERS REGULARLY FOLLOWING THE SIMPLE MANAGEMENT PRACTICES. Tests will not often provide information that leads to special action for farmers to take that is additional to what they should be doing.

Tests for Mastitis

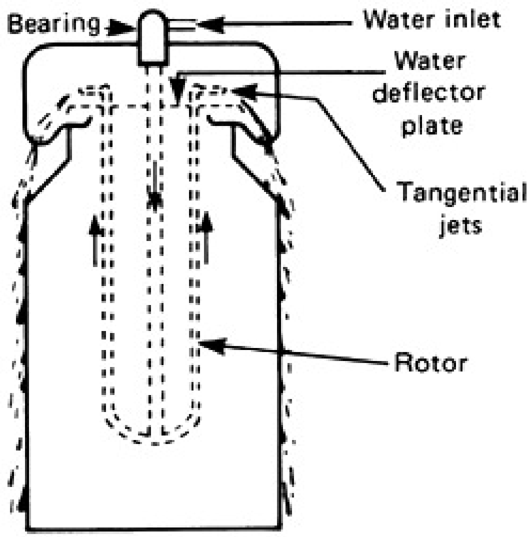
The tests for mastitis are either microbiological, to detect the causative pathogen (IDF Bull 132), or tests for the changes in the composition of milk which occurs with the inflammation. Tests for pathogens are not required routinely but are necessary to investigate special herd problems. The tests for changes in milk composition are simpler and some may be carried out on the farm (eg. California Mastitis Test). Electronic automated laboratory tests for somatic cells in milk (eg. using Fossomatic or Coulter equipment) can be used to provide regular information to farmers. Many other tests are also available which measure specific biochemical changes in the composition of milk (eg. Bovine serum albumin (BSA); antitrypsin test and NAGase test). The most widely used for routine screening of farm bulk milks is electronic cell counting which can readily be integrated with other tests of milk composition. When it is necessary to detect abnormal quarters on the farm a simple cowside test is useful (eg. CMT).

5. SYSTEMS OF MILKING

SYSTEM OF MILKING HAND MILKING is a labour intensive system in which capital investment, running costs, labour productivity and milking performance are minimal. Clean milking clothes, buckets, udders and hands are essential for good hygienic quality milk.

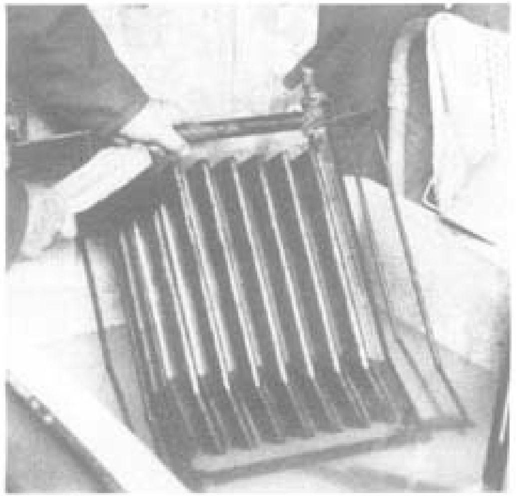


COOL the milk by immersing the cans of milk in clean, running water or by inserting an in-can turbine cooler. Alternatively, use a corrugated surface cooler connected to the water supply.



CLEAN the milking bucket and cooler by rinsing in clean water, scrubbing in hot (≥45°C) detergent/ disinfectant solution and finally rinsing in chlorinated (50 ppm) water.

Alternatively, after scrubbing in hot detergent solution, disinfect by immersion in hot (≥75°C) water for at east 3 minutes. Afterwards treat ancillary equipment similarly and allow all equipment to drain dry in a clean place.



SYSTEMS OF MILKING

Hand milking

Statistics from all major milk producing countries indicate an annual decline in the number and size of hand milked herds. Labour productivity in these herds is low with very few cows per person involved. Duration of milking each cow and the whole herd is protracted because each person milks cows one at a time with a relatively slow milk extraction rate compared with machine milking. These are factors which contribute to lower average lactation milk yields in hand milked herds. Nevertheless, for small herds, hand milking will usually be the method chosen because where there is sufficient labour available it can provide a satisfactory way of milk removal with minimal capital investment, equipment maintenance and cleaning.

During milking, hygiene standards require clean milking clothes and hooded milking buckets to prevent dust, dirt and udder hairs falling into the milk. Udders and tails need regular clipping. Before milking begins the foremilk is drawn and examined and visible dirt removed from udders

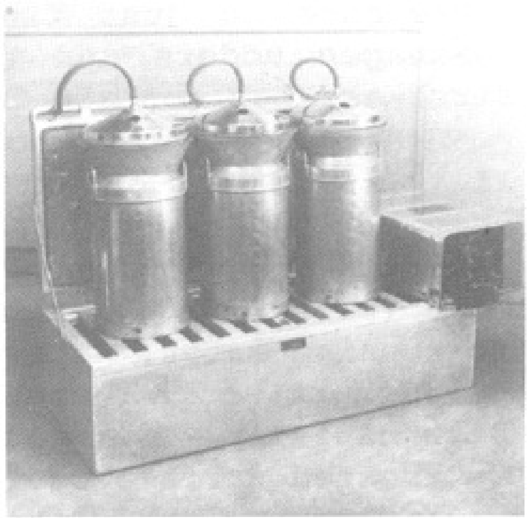
and teats by washing and drying with disposable paper towels. Milk with clean, dry hands using the full hand in preference to just finger and thumb, a practice which can lead to misshapen udders and teat injury. It is best to milk rear quarters first as they contain the higher proportion of milk.

Milk cooling methods will depend mainly on the local water supply. If the quality, quantity or temperature are unsuitable or unreliable, then the milk should be taken, within 3 hours of production, to a central depot for cooling. Where an unlimited free supply of clean, cold (below 15°C) water is available, the cans of milk can be immersed in running water. Water usage can be reduced and cooling rate increased by inserting a turbine in-can cooler into the cans of milk. Alternatively, the milk may be tipped and allowed to flow over a corrugated surface cooler connected to the water supply.

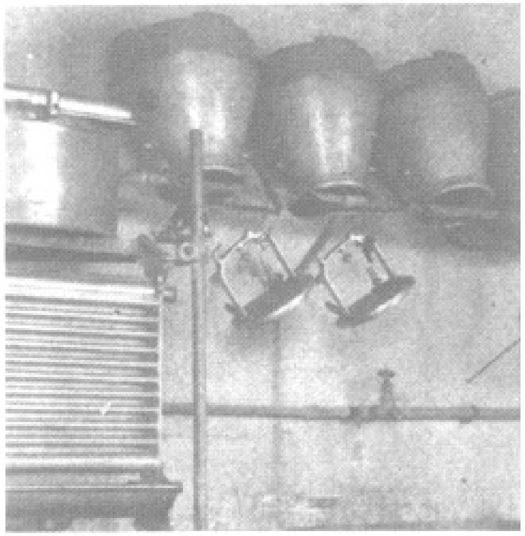
Cleaning the milking bucket and cooler is best done by an initial rinse in clean water immediately after milking, followed by scrubbing in a hot (45°C or above) detergent/disinfectant solution before finally rinsing in chlorinated water (50 ppm). Alternatively, after scrubbing the equipment in hot detergent solution, disinfect by immersing it in hot (above 75°C) water for at least 3 minutes. The foremilk cup, stool and udder washing equipment should be treated similarly afterwards. All equipment must be drained dry during the interval between milkings. (See page for further details).

BUCKET MACHINE MILKING was developed to mechanise cowshed milking. The units and ancillary equipment are carried from cow to cow and the milk transported, lifted and tipped manually. Therefore, although each operator uses 2 or 3 units, the system is laborious, restricting milking performance to about 30 cows per hour unless a trolley is used to enable an additional unit to be used.

COOL the milk either by inserting an in-can turbine cooler as soon as the milk cans are full or by carrying the milk to the dairy and pouring it over a surface cooler. Cooling efficiency can be improved and water saved by coupling the cooler to a chilled water unit.



CLEAN the milking equipment and cooler by rinsing in clean water, scrubbing in hot (≥45°C) detergent/disinfectant solution and finally rinsing in chlorinated (50 ppm) water. The ancillary equipment is treated similarly afterwards. Allow all equipment to drain in a clean place.



Bucket machine milking

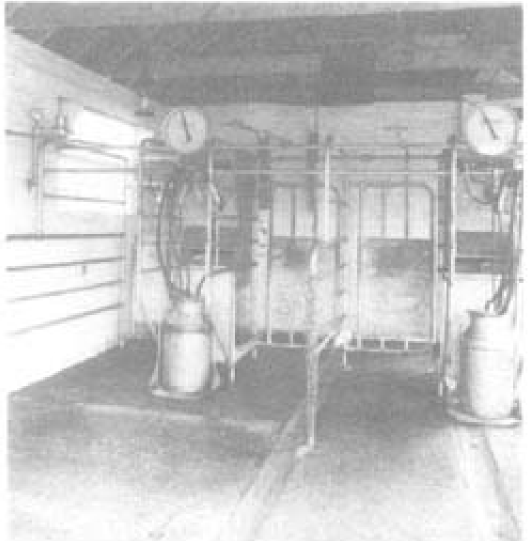
Bucket milking machines were the first major development in the mechanisation of milking systems and were designed particularly for herds kept in cowsheds. Each portable unit, consisting of a 15 litre capacity lidded bucket, pulsator and teat-cup assembly or cluster, requires manual attachment to a vacuum supply when it is moved from cow to cow during milking. Milk is tipped from the buckets into milk cans positioned in the dairy (milk room) or in the cowshed. The system is mechanically simple with relatively low investment, running and maintenance costs compared with milking machines in parlours. Milking performance is restricted in terms of cows milked per hour by the amount of work that must be carried out on each cow (the work routine). A high proportion of time and effort is spent walking from cow to cow and manually carrying equipment and transporting, lifting and tipping milk. (See page for further details). As a result, each operator is unlikely to be able to use effectively more than 2 or 3 bucket machine units and, consequently, will not milk more than about 30 cows per hour. A better performance will be achieved by using a trolley carrying the milk cans, spare milking machine bucket and udder preparation equipment. The trolley is moved along the cowshed as

milking proceeds. The consequent reduction in time and effort will allow an additional unit to be used thus raising potential performance to about 40 cows per hour.

Milk tipped direct to milk cans during milking is cooled by inserting an in-can turbine cooler when the cans are full. Otherwise, it will be necessary to carry the buckets of milk into the dairy and pour the milk over a corrugated surface cooler coupled to the water supply. Both methods are equally effective although using a surface cooler is more laborious. In either case, cooling efficiency is improved and water requirements reduced by connecting the cooler to a chilled water unit.

Cleaning bucket milking machines and the ancillary equipment is a three-part manual operation using detergent/disinfectant solutions. Immediately after milking, visible dirt and milk deposits on the outside of the equipment are removed with clean, cold water. Each unit is then connected to the vacuum supply and 10 litres of clean water drawn through the teat-cups into the unit bucket. This initial rinsing is followed by scrubbing all the milking equipment (except pulsators and pulse tubes) in a hot (not less than 45°C) detergent/disinfectant solution using 45 litres per 3 milking units. Volumes of water and quantities of chemicals used must be carefully measured (see page for further details). Finally, the equipment is rinsed in chlorinated water (50 ppm) and allowed to drain dry in a clean place. Ancillary equipment is treated similarly afterwards.

DIRECT-TO-CAN MILKING is a very simple, low cost system of milking, cooling and cleaning specially devised for abreast parlour milking. Milk is drawn directly from udder to milk can, eliminating milk lifting, carrying and tipping and thus enabling each operator to manage 4 or 5 milking units effectively.



COOL the milk by inserting an in-can turbine cooler connected to the piped water supply or to a chilled water unit.

CLEAN the equipment by removing visible dirt and deposits by rinsing in clear water, then loading the component parts (up to 3 units maximum) in a specially designed basket and lowering into a bin containing

3%–5% caustic soda solution which cleans and disinfects and also defats the rubberware. Before milking drain and remove all traces of solution by rinsing in chlorinated (50 ppm) water. Renew the solution monthly, adding EDTA to prevent hard water deposits. Caustic immersion cleaning can only be used with stainless steel clusters and lids

Direct-to-can milking

About 1950, many herds increased in size and moved from cowsheds to abreast parlour milking. The direct-to-can milking system was devised to meet this change and, consequently, it is applicable to this particular parlour. Compared with bucket machines, the capital investment, running costs and labour input are lower. As a complete system of milking, cooling and cleaning it is very simple indeed.

Milk is drawn direct from the udders to the milk cans via a specially designed lid which connects the milk can to the vacuum supply. Manual lifting, carrying and tipping of milk is eliminated with a consequent improvement in milking efficiency and performance. Therefore, each operator is able to manage a 4 unit, 8 stall or a 5 unit, 10 stall abreast milking parlour effectively. When full, the milk can is replaced with an empty one and milk cooling may begin. Cooling milk produced with the direct-to-can system is done simply by inserting an in-can cooler into the cans of milk and connecting it either to a clean, cold water supply or to a chilled water unit.

Cleaning direct-to-can milking equipment also provides substantial economies in labour and other costs of cleaning using a method developed specifically for the purpose. In addition to being bactericidal the cleaning treatment prevents milk fat accumulation in natural rubber components. When milking is finished, all visible dirt and milk deposits are removed from the milking equipment by rinsing in clean water. Next, the component parts of each unit, namely, the stainless steel lid and rubber gasket, two long rubber tubes and a stainless steel teatcup assembly are loaded into a purpose designed steel-mesh basket (up to a maximum of 3 units). The parts are positioned in the basket in such a way as to avoid any airlocks when lowered into a rubber or mild-steel bin containing a 3% to 5% caustic soda solution. A rubber lid covers the bin and the equipment remains in the solution until the next milking when it is lifted out to allow surplus solution to drain back into the bin. Before use, the equipment is removed from the bin and all traces of caustic soda solution removed by thorough rinsing in chlorinated (50 ppm) water. At monthly intervals the solution is renewed and ethylene diamine tetra-acetic acid (EDTA) added at the rate of 60gms to 45 litres of solution to prevent hard water deposits. After each milking the cooler and ancillary equipment are cleaned in the way described for bucket milking machine (See page 93). SEE PAGE 42 FOR SAFETY PRECAUTIONS.

PIPELINE MILKING is a high investment, low labour cost system, originally installed in cowsheds and milking barns but particularly suited to large and medium sized herds milked in parlours with bulk milk collection. Milk is transported direct from udder to refrigerated bulk milk tank for cooling and storage, and plant cleaning is done in-situ.

COOL the milk either by discharging it over a corrugated surface cooler, connected to the water supply or a chilled water unit, to gravitate to milk can underneath, or pump it direct from a milk receiving vessel to a refrigerated bulk milk tank in the dairy.

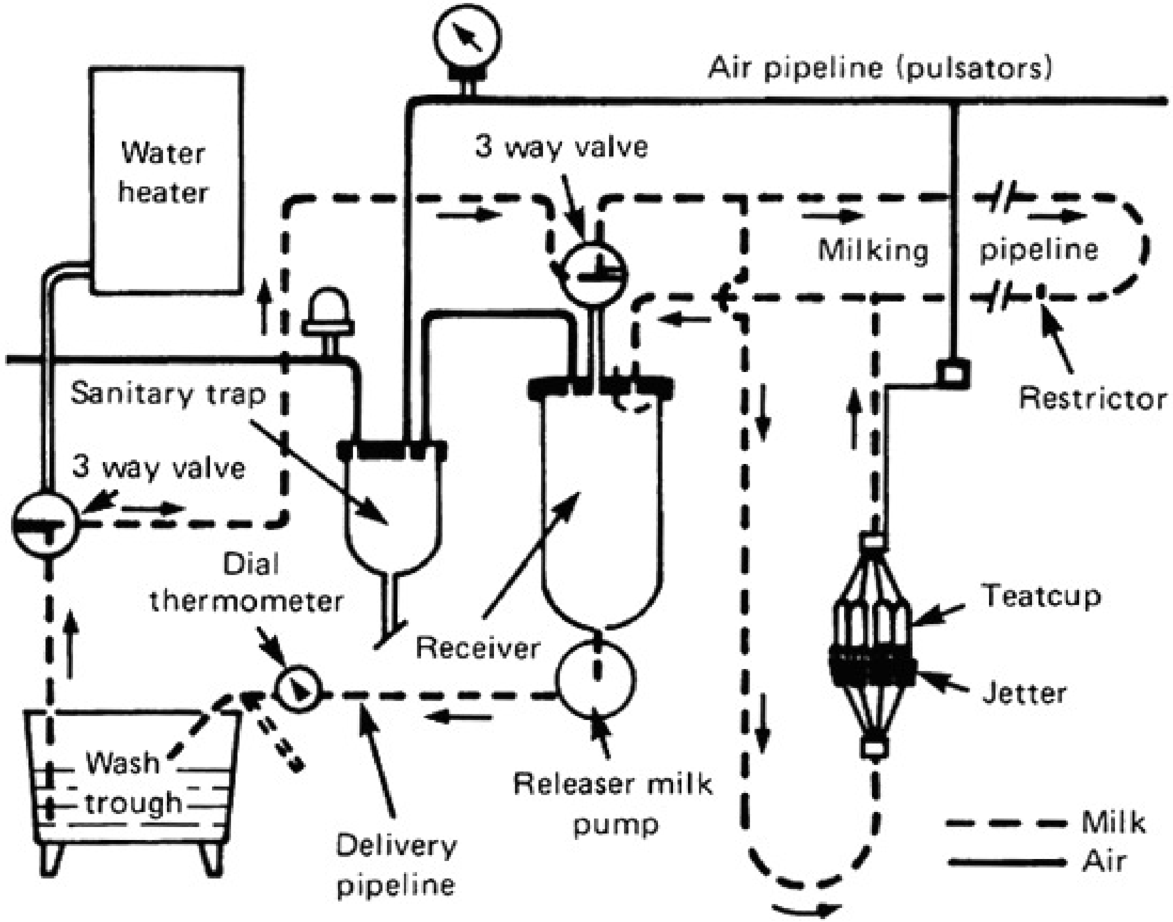
Pipeline milking

The introduction of bulk milk collection and refrigerated milk tanks on farms, together with the development of large static and rotary parlours for milking big herds, gave an impetus to pipeline milking systems which hitherto had been installed in large cowsheds and milking

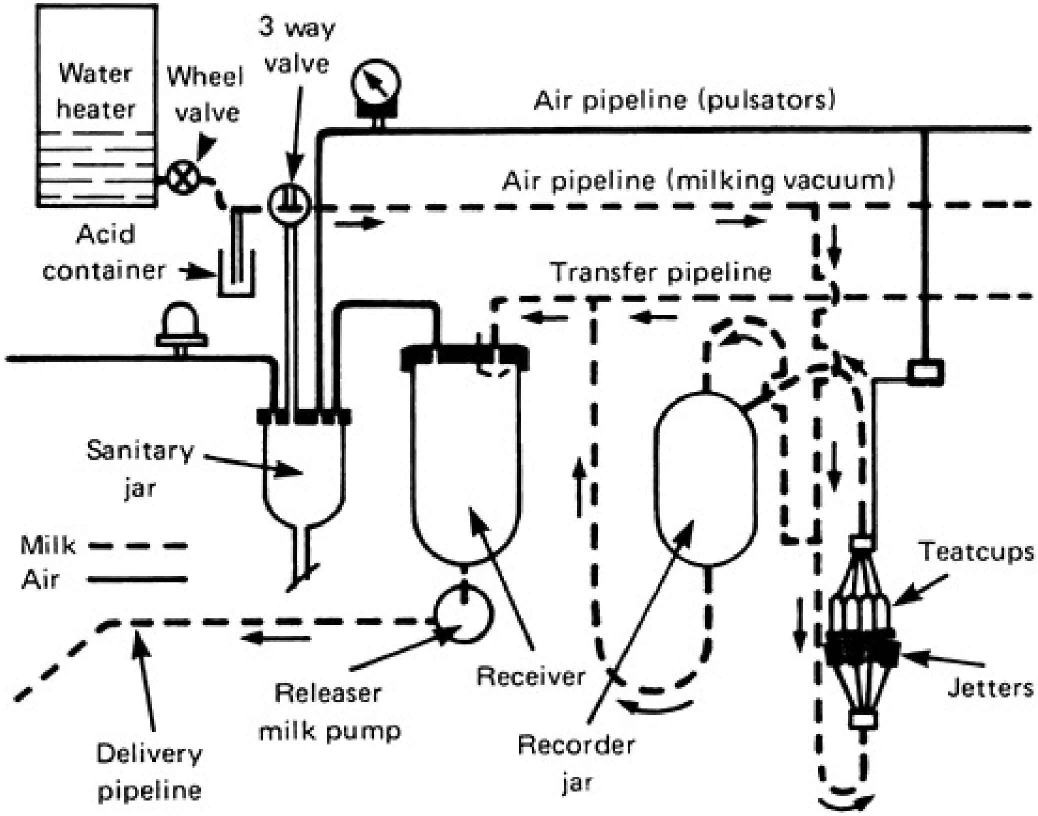
barns. The main advantages are that the milk is transported under vacuum from udder to dairy for cooling and storage and the cleaning and disinfection of the milking equipment can be done in-situ with very little manual involvement. In addition, devices can be inserted into the milking pipeline to reveal clinical signs of mastitis, indicate the milk yield from each cow, allow samples to be taken and automatically remove the cluster when milk flow ceases (thus eliminating overmilking). Internationally agreed standards prescribe the minimal diameter of pipelines to enable the milk to be transported without adversely affecting vacuum stability at the cluster. These comparatively high investment, low labour cost systems are the only practical alternative for large and medium sized herds milked in parlours, particularly where bulk milk collection is involved. During milking, operator work routines can be reduced to assisting cow entry and exit, udder preparation and cluster attachment so that milking performances of more than 85 cows per manhour can be achieved.

Milk cooling can be done by discharging the milk over a corrugated surface cooler connected to the water supply or a chilled water unit and collecting it in milk cans underneath. Alternatively, the milk can be pumped direct from a milk receiving vessel to a refrigerated bulk milk tank or via a pre-cooler to an insulated milk storage tank.

CLEAN and disinfect the pipeline milking plant in-situ by first removing manually any visible dirt and milk deposits from external surfaces and making the necessary adjustments to form a complete circuit between milking and milk transfer pipelines. Recirculate hot detergent/disinfection solution when the initial hot water rinse reaches 65°C at the discharge point, for 10–15 minutes at 10–15 litres per unit. Finally rinse with chlorinated water at 50 ppm.



Alternatively, use a single, once-through circulation of near boiling water at 15–20 litres per unit, and maintain a temperature of not less than 77°C FOR AT LEAST 2 minutes. During the first 2–3 minutes of flow, entrain 1 litre of diluted nitric or sulphamic acid



Cleaning and disinfecting pipeline milking equipment in-situ can be manually controlled or automatic using sequence timers which initiate the selected programme. Both the two available methods begin with the manual removal of visible dirt and milk deposits. Simultaneously, adjustments are made to enable a complete circuit to be formed incorporating the milking and milk transfer lines. Recirculation cleaning is a three-stage process incorporating a hot water pre-rinse which is discharged to waste until the water at the discharge point reaches 65°C. Detergent and disinfectant is then added to the hot water and the solution re-circulated (at 10–15 litres per unit) for 10– 15 minutes. Finally, chlorinated water is circulated once and discharged to waste. Acidified Boiling Water (ABW) cleaning relies solely on heat disinfection. It consists of a single, once-through circulation of near boiling water (at 15–20 litres per unit),

maintaining a temperature above 77°C on all milk contact surfaces for at least 2 minutes. During the first 2–3 minutes of flow 1 litre of dilute acid (70% w/w nitric acid or sulphamic acid crystals) is drawn into the boiling water to prevent deposition of hard water salts. Simple modifications are inserted into the pipeline circuitory to ensure a balanced flow of the hot solution at the desired rate to all milk contact surfaces. The refrigerated bulk milk tank is cleaned manually or mechanically.

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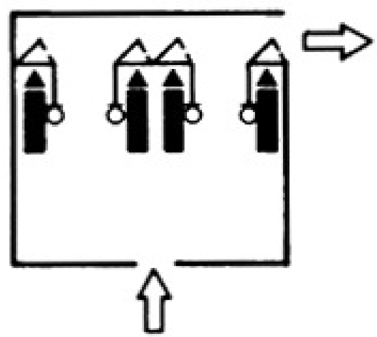
6. ORGANITATION OF MACHINE MILKING

MILKING PARLOUR INSTALLATIONS

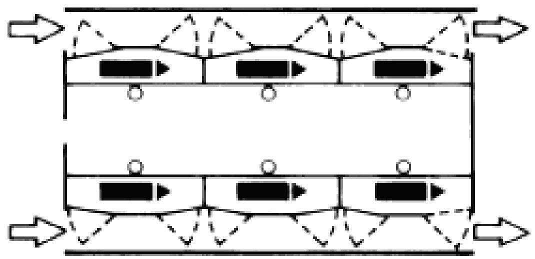
ABREAST PARLOURS

Construction costs are low per cow place. Operators must bend or crouch to perform most of the routine tasks on each cow. Milking efficiency is hindered by cows crossing the operator's work area. Cows in the exit passage are remote from the operator's control. Individual stalls allow individual attention during milking.



TANDEM PARLOURS

Construction costs are high per cow place. Operators can milk standing upright. Cows in the entry/exit passages are remote from the operator's control. Size of parlour and throughput are limited by the distance (2.5m) between udders. Individual stalls allow individual attention during milking. Food troughs can be easily reached and inspected by the operator.



ORGANISATION OF MACHINE MILKING

Milking machines were developed to meet demands for milking more cows more quickly using fewer people and less effort. Initially, this was achieved by the introduction of bucket units which were carried from cow to cow in traditional cowsheds or milking barns. Pipeline milking achieved considerable improvement in labour efficiency and reduction in manual lifting and carrying, but the major development was the change to parlours where the operators use stationary equipment to milk the cows as they pass through the installation during the course of milking.

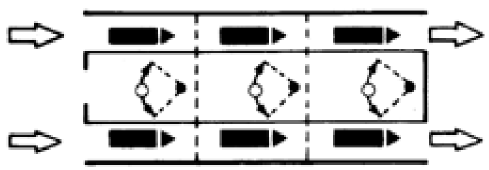
Milking parlour installations

At first, <u>static parlour</u> design followed the cowshed stall arrangement with the cows standing side-by-side and a milking unit positioned between each pair of stalls. In these <u>abreast</u> parlours, cows enter across the operator's working area and both are on the same floor level.

Later, a step was included to elevate the cows 0.3–0.4 m. Even with this addition milking cannot be carried out in an upright position and it was not until the introduction of the tandem parlour that genuine two-level milking became possible. In these, the cows stand head-to-tail in individual stalls on one or both sides of the operator's pit or work area with a floor level difference of 0.8 m. Each stall is fitted with an entry and exit gate giving access to and from a passage flanking the stalls. A simplified version of the tandem, known as the chute parlour, eliminates the need for separate access passages by having batch entry/exit of cows through the stalls when a division between each stall is opened. The number of cows in each batch equals the number of stalls on each side of the operator's pit. In both the tandem and the chute the distance between udders of adjacent cows is 2.5 m. This disadvantage renders large parlours impracticable, a problem which was solved by the development of the herringbone parlour. By standing a batch of cows in echelon formation at an angle of 30°–35° to the sides of the operator's pit, the distance between udders is reduced to 0.9 m. There are no individual stalls, the cows being restrained on the platform (or standing) by an entry gate, an exit gate and a rump rail parallel to the pit side. Herringbones have become popular in all major milk producing countries, being suitable for herds of 50 to 400 cows. In a recent modification, called the side-by-side, the cows stand at right angles to the pit so that 3 cows can occupy the space required for 2 cows in a herringbone.

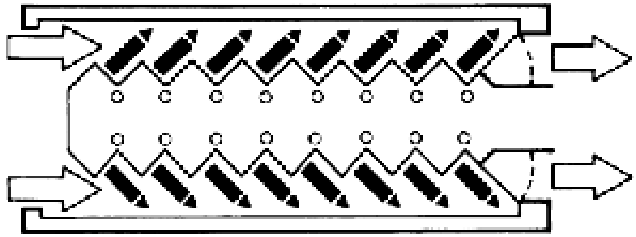
CHUTE PARLOURS

Cheaper, batch milking version of the tandem. Cows enter and leave through the stalls. Operator has control over cow entry/exit.



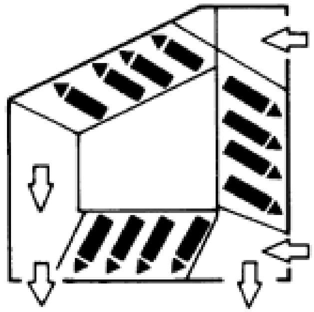
HERRINGBONE PARLOURS

Cows stand in echelon formation at 30°–35° to the operator's pit with no division between cows. Distance between udders is reduced to 0.9 m. Operator has control over cow entry/exit Cows enter and leave in batches. Suitable for herds of 50–400 cows.



TRIGON PARLOURS

Three-sided herringbone with, consequently, smaller batches causing less delay from a slow milking cow. Comparative parlour performance capacity will require 20%–25% fewer units and stalls than the conventional herringbone



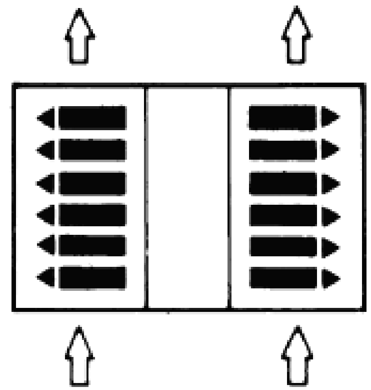
Four-sided (polygon) and, more recently, three-sided (trigon) herringbones have been built for larger herds. These multi-sided parlours economise in the number of units and stalls required compared with the conventional two-sided herringbone because fewer units are idle at any one time during milking. (eg. a 16/16 trigon is equivalent to a 20/20 herringbone in terms of parlour performance capacity). Also, the smaller batch size for a given number of units means that a slow milking cow has less effect on batch milking time.

Originally, rotary parlours were built for very large herds but more recently smaller ones have been designed to provide an alternative to the herringbone. As in the case of static parlours, the cows stand either side-by-side, ie, rotary abreast; head-to-tail ie, rotary tandem or in echelon formation, ie, rotary herringbone. During milking, cows walk onto a rotating platform

singly with the operator standing at the point of entry to prepare the udders for milking and attach the teatcup clusters. The cows leave the platform when rotation brings them opposite the exit passage, the clusters having been removed automatically when milk flow ceased. High capital and maintenance costs, mechanical faults and the introduction of automation into static parlours have all contributed to a declining interest in rotaries. The most successful version is undoubtedly the rotary abreast which has no moving parts on the platform, the cows face inwards towards the centre and the operator is positioned at the circumference of the platform to control cow entry.

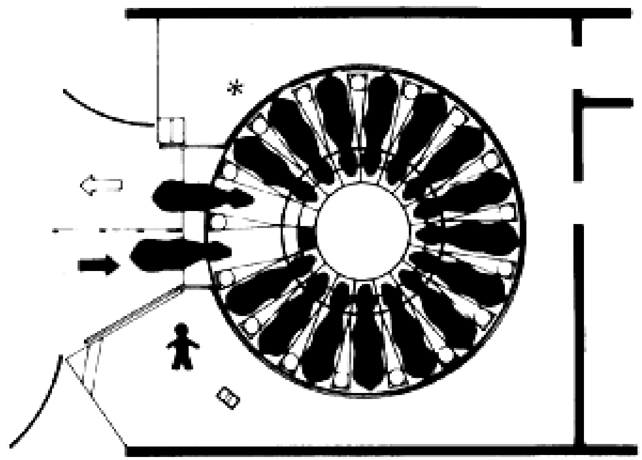
SIDE-BY-SIDE PARLOURS

Modification of the herringbone. Cows stand at right angles to the operator's pit, so that 3 cows occupy the length required for 2 in the herringbone. Cows must be milked through the back legs.



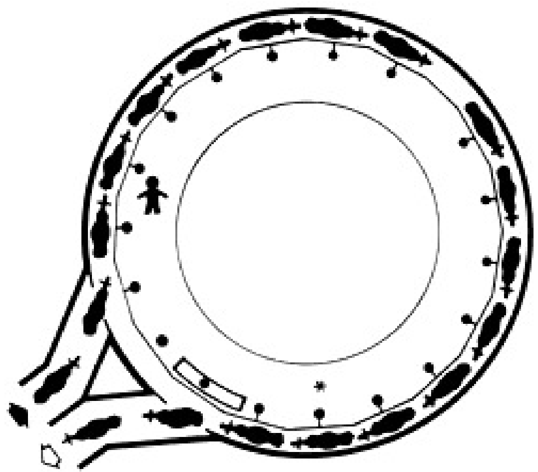
ROTARY ABREAST

Least expensive rotary per cow place in terms of cost and space requirement. Cows face inwards separated by static tubular metal divisions. No moving parts on the platform. Operator standing at the platform perimeter can assist cow entry but cannot see the cows during rotation.



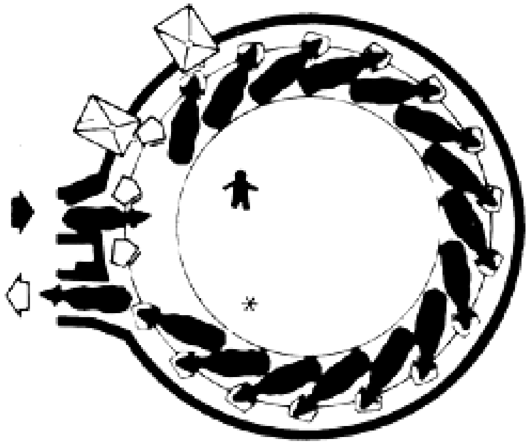
ROTARY TANDEM

Most expensive per cow place in terms of cost and space requirement. Cows stand nose-to-tail in stalls circling the operators work area. Operator cannot assist cow entry but can see all cows easily during rotation.



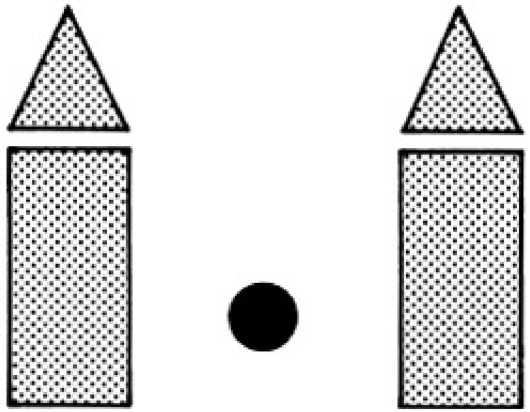
ROTARY HERRINGBONE

Cows stand in echelon formation facing outwards around a central work area. Designs vary from simple yoke ties only on the platform to rotationally operated moving divisions which position the cows and allow entry and exit.

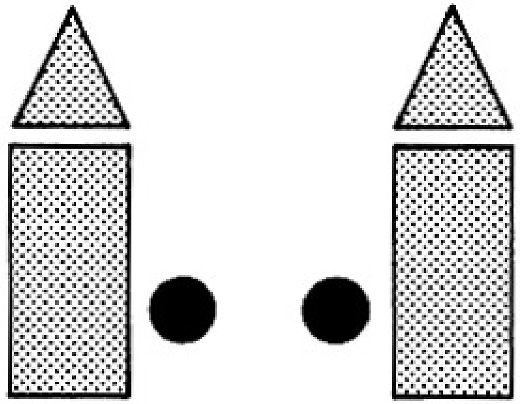


TYPES OF PARLOUR

ONE MILKING UNIT PER TWO STALLS (½) Each milking unit is shared between two stalls. Comparatively short unit idle time of 0.2 mins. Slow milking cows can delay throughput.



ONE MILKING UNIT PER STALL (1/1) Each stall has a milking unit. More costly installation than ½. Throughout milking, about 50% of units will, on average, be idle with an average unit idle time of 1.2 mins. “Doubling-up” the number of units is equivalent to adding one more unit (eg. 5/10 to 10/106/12) in terms of available milking time per cow. Work routine time and feeding time per cow will be unaffected (in batch milking). Operators can select sequence of cluster attachment. More regular interval between udder preparation and cluster attachment.



Types of milking parlour

Even though there are several parlour designs and configurations there are only two basic types; those having one milking unit to each pair of stalls (eg. 5 units, 10 stalls), or one unit to each stall (eg. 10 units, 10 stalls). With the exception of rotaries, trigons and polygons, milking parlours can be of either type. In recent years, many 1 unit per 2 stall parlours have been "doubled-up" to the 1 unit per 1 stall version and it is important that the effect of this change is understood, particularly in relation to comparative parlour performance capacity. The operator's work routine time (ie. the time available to carry out the routine jobs on each cow) is unaffected. This is because, in the doubled-up version about 50% of the units will, on average, be idle at any one time, and the content of the work routine will be unchanged (see multiple activity charts). Also unaffected is the available eating time for cows in parlours where batch milking is practised, (eg. the herringbone). Although the average interval between cluster attachment and removal (ie. the available milking time per cow) becomes greater in the doubled up version for a given performance level, this advantage can be exploited only if the operator had previously been waiting for cows to milk out. In terms of performance capacity (ie. available milking time per cow) doubling up a 5/10 herringbone to a 10/10 for example, is equivalent to adding one more unit to the 5/10 to make a 6/12 (see page).

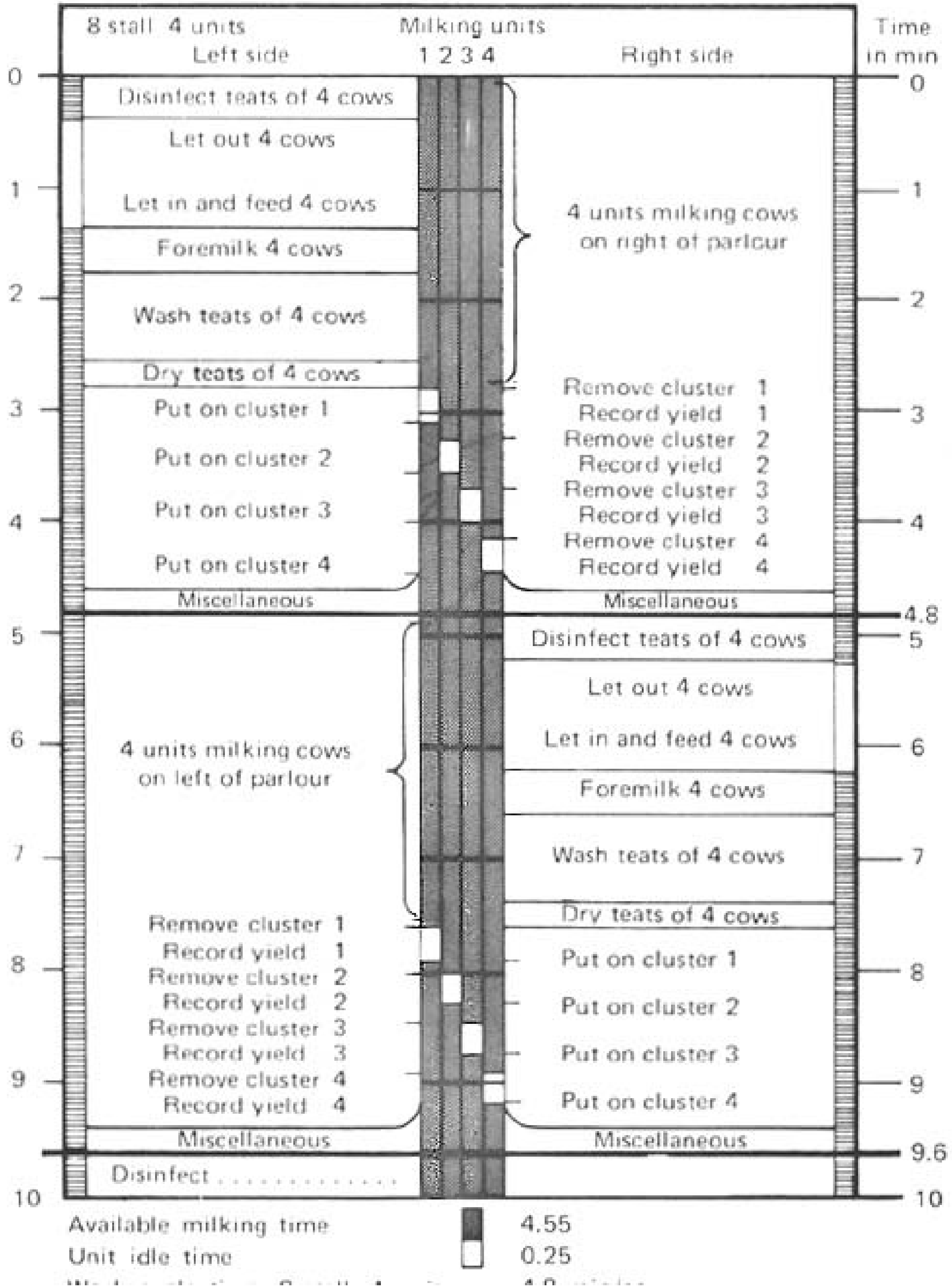
Other advantages of one unit per stall installations are that delays caused by slow milking cows can be minimised because the operator can select the sequence of cluster attachment to cater for known differences in the milking out times of cows; the interval between cow preparation and cluster attachment is likely to be more constant and, milk flow can be gravity assisted to pipelines below udder level.

The expense of doubling-up will achieve only a marginally improved throughput created by an increase in the available milking time per cow, improved flexibility in the use of the milking units and a work routine unimpeded by equipment hanging from the centre of the operator's work area.

When a new 1 stall per 1 unit installation is proposed in preference to a 1 unit per 2 stall alternative, these same marginal advantages are relevant together with a small saving in building space which occurs. For example a 10/10 herringbone requires approximately 1 m less length of building than the 6/12 equivalent.

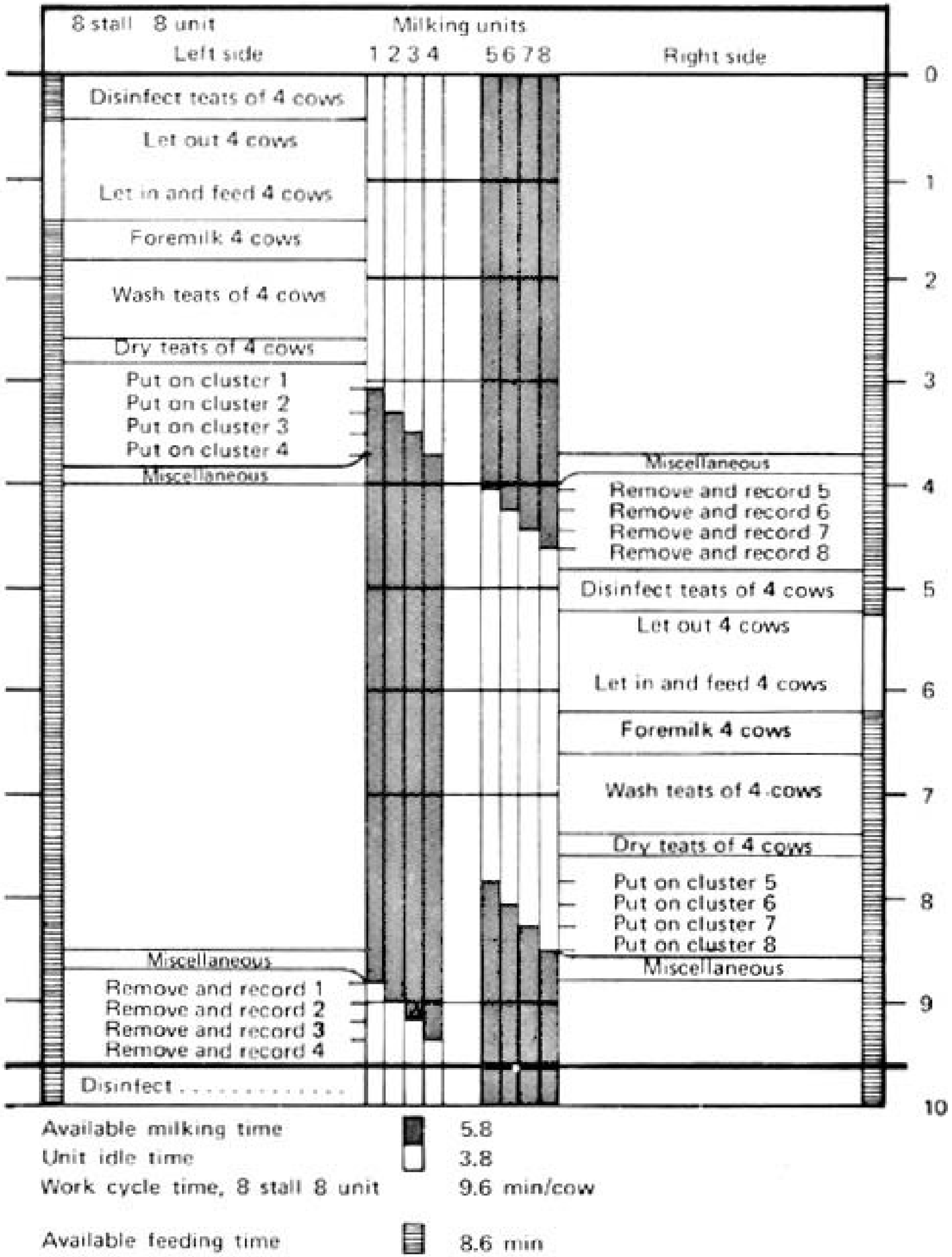
PARLOUR MILKING PERFORMANCE	WORK ROUTINE TIME	SIZE OF HERRINGBONE (units/stalls)		
		8/8	10/10	12/12
		5/10	6/12	7/14
(cows/hour)	(mins/cows)	AVERAGE	AVAILABLE MILKING TIME (mins/cow	
50	1.2	5	6	7
60	1.0	4	5	6

MULTIPLE ACTIVITY CHART 4/8


8 stall 4 units
Left side
Milking units
1 2 3 4
Right side
Time in min
Disinfect teats of 4 cows
Let out 4 cows
Let in and feed 4 cows
Foremilk 4 cows
Wash teats of 4 cows
Dry teats of 4 cows
Put on cluster 1
Put on cluster 2
Put on cluster 3
Put on cluster 4
Miscellaneous
4 units milking cows on right of parlour
Remove cluster 1
Record yield 1
Remove cluster 2
Record yield 2
Remove cluster 3
Record yield 3
Remove cluster 4
Record yield 4
Miscellaneous
4.8
Disinfect teats of 4 cows
Let out 4 cows
Let in and feed 4 cows
Foremilk 4 cows
Wash teats of 4 cows
Dry teats of 4 cows
Put on cluster 1
Put on cluster 2
Put on cluster 3
Put on cluster 4
Miscellaneous
4 units milking cows on left of parlour
Remove cluster 1
Record yield 1
Remove cluster 2
Record yield 2
Remove cluster 3
Record yield 3
Remove cluster 4
Record yield 4
Miscellaneous
9.6
Disinfect . . . .
0 1 2 3 4 5 6 7 8 9 10
Available milking time 4.55
Unit idle time 0.25

Work cycle time, 8 stall, 4 unit	4.8 min/cow
Available feeding time	8.6 min

MULTIPLE ACTIVITY CHART 8/8


8 stall 8 unit
Milking units
Left side
1 2 3 4
5 6 7 8
Right side
Disinfect teats of 4 cows
Let out 4 cows
Let in and feed 4 cows
Foremilk 4 cows
Wash teats of 4 cows
Dry teats of 4 cows
Put on cluster 1
Put on cluster 2
Put on cluster 3
Put on cluster 4
Miscellaneous
Remove and record 5
Remove and record 6
Remove and record 7
Remove and record 8
Disinfect teats of 4 cows
Let out 4 cows
Let in and feed 4 cows
Foremilk 4 cows
Wash teats of 4 cows
Dry teats of 4 cows
Put on cluster 5
Put on cluster 6
Put on cluster 7
Put on cluster 8
Miscellaneous
Miscellaneous
Remove and record 1
Remove and record 2
Remove and record 3
Remove and record 4
Disinfect . . . .
0
1
2
3
4
5
6
7
8
9
10
Available milking time 5.8
Unit idle time 3.8
Work cycle time, 8 stall 8 unit 9.6 min/cow
Available feeding time 8.6 min

Milking performance

Milking installations, like most other agricultural machinery, should be purchased on the basis of cost and required performance or throughput. During each milking the work done by the operator remains virtually the same, whereas the amount of milk produced per hour will fluctuate throughout the year. Therefore, the throughput of a milking installation is best measured in terms of cows milked per hour and performance as cows milked per manhour. For example, if two operators milking together achieve a throughput of 120 cows per hour that is a performance of 60 cows per manhour. The required rate of throughput is determined initially by three management decisions:

1. **The maximum number of cows to be milked.**
2. **The time available for milking at each end of the day, taking into account the other work to be done by those also doing the milkings.**
3. **The number of operators milking together and the degree of mechanization and automation. Other things be ng equal, two operators should double the throughput but would require twice the parlour size.**

In herds large enough to warrant division of labour, the trend is towards one operator milking with increasing mechanization and automation. It has been shown that long milking shifts do not affect performance adversely, but in most herds where milking and the work between milkings is done by the same people, duration of milking is usually limited to 1–2 hours. The three factors that determine the throughput or performance (P) of a milking installation are:

1. The average milking-out time of the cows (MOT).

The milking-out time plus the time that units are not attached to cows (ie. unit idle time) is

called the unit time (UT) and this prescribes the maximum number of cows that can be milked in one hour using one unit

$$P \text{ (cows milked/hour)} = \frac{60}{UT}$$

Although milking times of individual cows vary considerably and will be affected by vacuum level and pulsation characteristics the most important factor influencing the average milking-out time of the cows in a herd is the average herd milk yield; the higher the average yield the longer the average MOT. The relationship between these factors is expressed as:

$$t = 0.21y + 2.75$$

where t = herd milking time (mins/cow)
and y = average herd milk yield (litres/cow)

Thus, if the average yield of milk at a milking is 11 litres the average milking-out time will be $0.21 \times 11 + 2.75$ or about 5 minutes per cow.

2. The number of milking units (N) per operator.

Providing each milking unit is used to maximum efficiency the total number of cows milked per hour (P) will be the number of units (N) times the number that can be milked with one unit in an hour. Therefore for an installation:

$$P = N \times \frac{60}{UT}$$

There is a limit to the number of units that can be used effectively by one operator and if this is exceeded there will be an increase in the unit idle time or the units will be idle or left on the cows or hanging up after milk flow has ceased. This will increase the unit time (UT) and consequently lower performance (P).

3. The operator's work routine time (WRT).

This is the average time spent on the various tasks associated with milking each cow (ie. attaching and removing clusters, udder preparation, etc.). If the operator spends 2 minutes working on the routine tasks on each cow, the number of cows that can be milked in an hour cannot exceed 60å2 = 30 cows/hour. However, if the work routine time can be reduced to 1 minute the performance can be increased to 60 cows/hour providing the operator has a sufficient number of units. In most large parlours it is the work routine time that limits the performance.

Planning the correct operation of any milking installation is mainly a matter of adopting the correct work routine for the number of units to give the required performance. The relationships are shown in the Table for a herd which has an average unit time (ie. milking-out time plus machine idle time) of 6 minutes and calculated from P = N × 60 and $P = \frac{60}{WRT}$

Number of unites (N)	Unit Time (UT) (mins)	Performance (P) (cows/hour)	Work Routine Time (WRT) (mins/cow)
2	6	20	3
4	6	40	1.5

8	6	80	0.75

Thus in this herd an operator will milk 20 cows/h with 2 units providing the work routine does not exceed 3 minutes on each cow. However if 4 or 8 units are used then performances of 40 or 80 cows/h can be obtained if the work routines are reduced to 1.5 or 0.75 min respectively. It is important to appreciate that if 8 units are used and the work routine time remains at 3 minutes the performance cannot exceed 20 cows/h.

In cowshed milking, although the cows are stationary, operator time is spent walking from cow to cow, carrying udder preparation and milking equipment and transporting milk to the dairy. A substantial proportion of this time (25%) can be saved by placing milk cans, preparation equipment and spare milking machine buckets on a trolley which is moved as milking proceeds along the shed. If a pipeline is installed, milk can be transported direct from cow to dairy by vacuum, thereby allowing time to use additional milking units. Standard work routine times for the three alternatives are:

Bucket milking machine :	2.0 mins/cow	
Bucket milking machine with trolley :	1.5	"
Pipeline milking machine :	1.0	"

In parlour milking, work routine times are minimised by reducing operator movement and either mechanising or fully automating jobs like cluster removal and teat disinfection. The effect is to halve a standard 1.2 minute WRT and thus raise potential throughput or performance above 85 cows per hour as shown in the Table.

Standard Work Routine Times Element

Element	mins/cow	Element	mins/cow
Let in cow	0.2	Let in cow	0.1
Foremilk	0.1	In-line filter	-
Wash & dry udder	0.2	Wash & dry udder	0.2
Attach cluster	0.2	Attach cluster	0.2
Remove cluster	0.1	Automatic cluster removal	.
Disinfect teats	0.1	Automatic teatdisinfection	.
Let out cow	0.2	Let out cow	0.1
Miscellaneous	0.1	Miscellaneous	0.1
Total	1.2	Total	0.7

PLAN PARLOUR SELECTION		EXAMPLES	
in a methodical way		Herd X	Herd Y
A.	Estimate the maximum number of cows that will be in milk	75	225
B.	Decide on the maximum duration of milking (hours)	1½	1½
C.	Calculate the required throughput A-B (cows/hour)	50	150
D.	Decide on the number of operators to be used	1	2
E.	Calculate the required performance C-D (cows/manhour)	50	75
F.	Estimate the maximum peak milk yield at a milking (kg or litres/cow)	20	14
G.	Determine (from E and F) the required parlour type and size (units and	14/14 or	12/12 or

	stalls) per operator	8/16	7/14
H.	Determine the available work routine time 60-E (mins/cow) and decide on the content of the work routine (from standard times) and the degree of automation required	1.2	0.8

Selection and use of milking parlours

In milk producing countries where labour is either a scarce or costly resource the management of milking installations is an important aspect of farm management. Very large herds employ specialist milkers whose work is solely milking the cows and certain associated jobs such as record keeping and cleaning the milking premises and equipment. All other cow management tasks such as feeding, re-littering and manure removal are done by other people. In numerous smaller herds the milkers carry out many of these other tasks in the interval between morning and evening milking but even here labour economy in milking is important if all the many jobs in cow-management are to be completed each day. When plans are being prepared for a new milking system, management's first task is to decide on the duration of milking, and this determines the required rate of milking. For example, if a herd of 120 cows is to be milked in 2 hours, they must be milked at the rate of 60 cows/hour. This can be achieved only by installing the correct number of milking units (per operator) for the mean peak yield level and then planning the work to be done on each cow during milking to obtain the necessary work routine time. The following example of two herds, each with an average 300 day lactation and milk yield of 6000 litres per cow illustrates the point.

HERD A: All the year round calving policy; 12 hourly milking intervals. 20 litres/cow/day or 10 litres/cow/milking (mean peak yield)

HERD B: All cows calve within 3 months; 16 hour and 8 hour milking intervals

30 litres/cow/day for first 100 days or 20 litres/cow at morning milking (mean peak yield)

For Herd B it is necessary to plan for the longer milking-out time per cow requirement which means more milking units than for Herd A to achieve the same performance.

Using $P = \frac{N \times 60}{UT}$ and $MOT = 0.21\,y + 2.75$

(+0.2 mins machine idle time)

then Herd A requires 5 units (eg. 5/10) and Herd B requires 8 units (eg. 8/16).

Similar calculations have been tabulated to show the correct size of milking installation for a range of three milking performance. The Table shows the relationship between performance (P) work routine time (WRT) and static herringbone milking parlour capacity in terms of mean milk yield (kg/cow) up to which maximum performance is possible

		STATIC HERRINGBONES (units/stalls)				
		8/8	10/10	12/12	14/14	16/16
P cows per hour	WRT mins per cow	5/10	6/12	7/14	8/16	10/20
		Mean milk yield (kg/cow) up to which maximum performance is possible *				
50	1.2	14	16	18	20	24
60	1.0	11	14	16	18	22
75	0.8	9	11	14	16	20

(* above these yields the milking-out times are too long for theperformance to be achieved.)

Two further examples will indicate how to use the Table. If a herd has an average peak yield of 16 litres/cow at a milking and a performance of 75 cows/hour is required the parlour should be either 14 units/14 stalls or 8 units/16 stalls. If 50 cows/hour is all that is required then a 10 unit/10 stall or 6 unit/12 stall parlour is sufficient. Obviously neither performances will be achieved unless the work routine times are 0.8 mins in the first example and 1.2 minutes in the second example. There are other general principles which can also be illustrated by the Table. To maintain performance when mean herd milk yields increase, or to increase performance at a constant herd milk yield, it is necessary to increase the number of units used. In order to increase performance, it is essential to reduce the work routine time per cow proportionally.

INDEX

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1. Animal breeding: selected articles from World Animal Review, 1977 (C* E* F* S*)
2. Eradication of hog cholera and African swine fever, 1976 (E*F*S*)
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12. Ruminant nutrition: selected articles from World Animal Review, 1978 (C* E* F* S*)
13. Buffalo reproduction and artificial insemination, 1979 (E**)
14. The African trypanosomiases, 1979 (E* F*)
15. Establishment of dairy training centres, 1979 (E*)

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18. Feed from animal wastes: state of knowledge, 1980 (E*)
19. East Coast fever and related tick-borne diseases, 1980 (E* S*)

20/1. Trypanotolerant livestock in West and Central Africa, 1980. Vol.1 - General study (E* F*)

20/2. Trypanotolerant livestock in West and Central Africa, 1980. Vol.2 - Country studies (E* F*)

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24. Animal genetic resources - conservation and management, 1981 (E*)
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26. Camels and camel milk, 1982 (E*)
27. Deer farming, 1982 (E*)
28. Feed from animal wastes: feeding manual, 1982 (E*)
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30. Sheep and goat breeds of India, 1982 (E*)
31. Hormones in animal production, 1982 (E*)

32. Crop residues and agro-industrial by-products in animal feeding, 1982 (E/F*)
33. Haemorrhagic septicaemia, 1982 (E* F*)
34. Breeding plans for ruminant livestock in the tropics, 1982 (E* F* S*)
35. Off-tastes in raw and reconstituted milk, 1983 (E* F* S*)
36. Ticks and tick-borne diseases: selected articles from World Animal Review, 1983 (E* F* S*)
37. African animal trypanosomiasis: selected articles from World Animal Review, 1983 (E* F*)
38. Diagnosis and vaccination for the control of brucellosis in the Near East, 1983 (Ar* E*)
39. Solar energy in small-scale milk collection and processing, 1983 (E* F*)
40. Intensive sheep production in the Near East, 1983 (Ar* E*)
41. Integrating crops and livestock in West Africa, 1983 (E* F*)
42. Animal energy in agriculture in Africa and Asia, 1984 (E/F*)
43. Olive by-products for animal feed, 1985 (Ar* E* F* S*)
44/1. Animal genetic resources conservation by management, data banks and training, 1984 (E*)
44/2. Animal genetic resources: cryogenic storage of germplasm and molecular engineering, 1984 (E*)
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