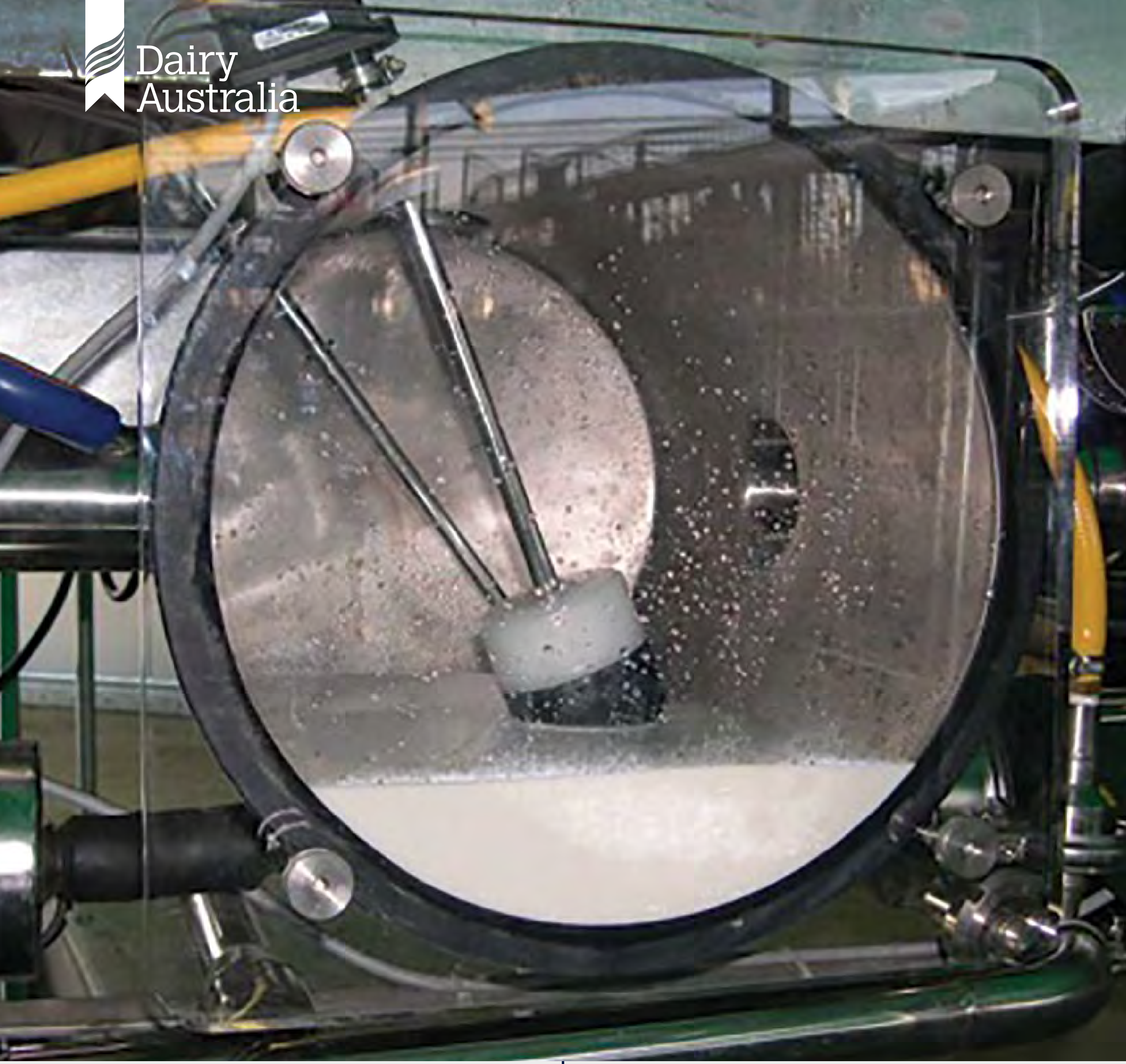

Australian dairy hygiene handbook

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About this handbook

The intention of the *Australian dairy hygiene handbook* is to act as a reference manual for farm dairy hygiene in Australian conditions. It draws on the experience, expertise and knowledge from a range of local and international resources. The information presented is based on the science of cleaning and how it can be applied in Australia where water quality and water availability have such a dominating influence. It also acknowledges the impact of factors such as regulations and legislation, available detergents and sanitisers, and the demands of consumers, on cleaning approaches.

Whilst on-farm milk cooling is highly influential to raw milk quality, this is not addressed in detail as the focus of this handbook is specifically dairy hygiene.

Disclaimer

The content of this publication including any statements regarding future matters (such as the performance of the dairy industry or initiatives of Dairy Australia) is based on information available to Dairy Australia at the time of preparation. Dairy Australia does not guarantee that the content is free from inadvertent errors or omissions and accepts no liability for your use of or reliance on this document. You should always make your own inquiries and obtain professional advice before using or relying on the information provided in this publication, as that information has not been prepared with your specific circumstances in mind and may not be current after the date of publication.

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Cover photo: Checking the wash cycle (G. Hakim)

Dairy Australia

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TERMINOLOGY

A consistent approach has been applied in this handbook to the more commonly used words and terms associated with dairy hygiene (**Figures 1** and **2**).

Figure 1 The dairy hygiene approach

Dairy hygiene
All activities, processes and equipment associated with cleaning the milking machine, bulk milk vat and other milk harvesting equipment

- **Cleaning method**
  The type of equipment used in cleaning (e.g. Jetter)
- **Cleaning program**
  The activities and procedures deployed in cleaning
  - **Wash routine**
    The steps undertaken when cleaning
  - **Wash program**
    The procedure of the cleaning cycles

Figure 2 The distinction between cleansers and sanitisers

Dairy cleansers and sanitisers

- **Cleansers**
  - **Alkali detergent**
    A product that combines the functions of an alkaline detergent. Can be chlorinated or non-chlorinated
  - **Acid detergent**
    A product that functions as an acid detergent
- **Sanitisers**
  - **Sanitiser and detergent**
    A product that combines the functions of a sanitiser and a detergent. Can be acid or alkali based
  - **Sanitiser**
    A product that functions as a sanitiser only. Can be chlorinated or non-chlorinated

Abbreviations

AMMTA	Australian Milking Machine Technicians Association
APHA	American Public Health Association
APVMA	Australian Pesticides and Veterinary Medicines Authority
AS	Australian Standard™
BMCC	Bulk milk cell count
cfu	Colony forming units
CIP	Cleaning in place
HWS	Hot water service
ibc	Individual bacterial count
ISO	International Standards Organisation
N/A	Not applicable
QA	Quality assurance
QAC	Quaternary ammonium compound
TPC	Total plate count
WHS	Workplace Health and Safety

01

THE IMPORTANCE OF DAIRY HYGIENE

INTRODUCTION

Consumers in our competitive domestic and export markets are demanding higher quality dairy products. Meeting these demands requires a high quality raw milk material.

This consumer pressure is passed on to the dairy farmer through:

1. Legal requirements to meet basic food safety standards
2. Trade regulations and market access requirements
3. Incentive payments or penalties based on milk quality
4. Product specification requirements.

Microbial contamination is a major cause of poor quality milk. One of the main sources of contamination is associated with poor milking machine hygiene, resulting from an ineffective cleaning program and/or cleaning method.

MILK AND MILK QUALITY

Milk composition

Milk contains water, lactose, fat, protein, minerals, and vitamins.

Cow's milk is composed of:

- 87.6% water
- 4.7% carbohydrate (predominantly lactose)
- 3.8% fat
- 3.3% protein
- 0.6% vitamins and minerals

The relative composition of these milk components varies between species and between breeds **(Table 1**).

Milk characteristics

Milk proteins is divided into two categories; casein (80%) and whey (20%). Casein is present in the form of very small complexes known as micelles.
The major whey proteins in cow milk are beta-lactoglobulin and alpha-lactalbumin.

Lactose is the major milk carbohydrate (sugar) in most species.

Table 1 Milk composition of different dairy species and breeds

	Fat (%)	Protein (%)	Protein: fat ratio	Lactose (%)	Minerals (%)	Total solids (%)	Water (%)
Cattle:							
Ayrshire	4.1	3.6	0.9	4.7	0.7	13.1	86.9
Brown Swiss	4.0	3.6	0.9	5.0	0.7	13.3	86.7
Guernsey	5.0	3.8	0.8	4.9	0.7	14.4	85.6
Holstein	3.5	3.1	0.9	4.9	0.7	12.2	87.8
Jersey	5.5	3.9	0.7	4.9	0.7	15.0	85.0
Goat	3.5	3.1	0.9	4.6	0.8	12.0	88.0
Sheep	5.3	5.5	1.0	4.6	0.9	16.3	83.7
Buffalo	7.4	4.1	0.6	5.0	0.9	17.4	82.6

Milk quality

Descriptors of milk quality include:

- colour and texture
- flavour and odour
- composition
- nutritional value
- manufacturing or processing properties
- presence of any 'abnormalities' (e.g. high numbers of somatic cells, blood)
- contamination by foreign substances (e.g. bacteria, bacterial enzymes, antibiotics, chemicals, soil).

Milk quality is affected by many factors such as cow diet, health and teat contamination, the harvesting, handling and storage process. The effect can be compounded when multiple factors are at play. For example, poor dairy hygiene can increase the bacterial load entering the milk during the harvesting process. Slow and ineffective cooling of the milk will provide conditions conducive to growth of these bacteria, leading to high bacterial numbers and poor quality milk.

Measurement parameters

There are many ways of measuring the quality of milk. Some are subjective, such as sensory measures (smell, taste, visual), and others are objective (composition, culturing, somatic cell count, colostrum, temperature, freezing point). When it comes to dairy hygiene, the focus is on determining the level of contamination of bacteria in the milk. There are many different types of bacteria – with different characteristics – that can contaminate milk and each can have a different consequence on milk quality. Several different tests are performed to identify different types of bacteria; the most commonly used in Australia are listed in **Table 2**.

Table 2 Cleaning-related milk quality tests

Test	What the test measures	How the test is conducted (or test procedure)	Typical limit for premium quality	Applicable standard
Total Plate Count	Total number of bacteria colonies* that have formed (from live, viable bacteria)	Bulk milk samples are incubated on agar plates @30°C for 72h. After incubation the colonies of bacteria are counted visually or electronically	<20,000 (cfu/ml**)	AS 5013.5 Microbiology of food and animal feeding stuffs—Horizontal method for the enumeration of microorganisms—Colony count technique at 30°C
Bactoscan	Total number of bacteria (alive or dead)	Bulk milk sample is electronically scanned and all bacteria are counted	<80,000 (ibc/ml#)	ISO 16297/IDF 161. Milk-Bacterial count-Protocol for the evaluation of alternative methods. AS 5013.5 Microbiology of food and animal feeding stuffs (see above)
Thermodurics	Total number of bacteria that have survived pasteurisation and have formed colonies	Bulk milk samples are first pasteurised at 63.5°C for 30 mins then incubated on agar plates @30°C for 72h. After incubation the colonies of bacteria are counted visually or electronically	<2,000 (cfu/ml)	AS 5013.28. Food microbiology-Examination of specific products-Liquid milks and creams. AS 5013.5 Microbiology of food and animal feeding stuffs (see above)
Thermophiles	Total number of bacteria that have survived pasteurisation and can grow at high temperatures	Bulk milk samples are incubated on agar plates @55 °C for 72h. After incubation the colonies of bacteria are counted visually or electronically	<1,000 (cfu/ml)	SMEDP 8.040 Tests for groups of microorganisms – Thermophilic Bacteria (SMEDP is Standard Methods for the Examination of Dairy Products, by the APHA – American Public Health Association)
Spore Count	Total number of bacteria that have survived pasteurisation and can grow at refrigeration temperatures	No standard method. Procedure similar to that for thermodurics except a range of incubation temperatures (>80°C) may be applied	<100 (cfu/ml)	Microbiological examination for dairy purposes. Methods for detection and/or enumeration of specific groups of microorganisms. Enumeration of aerobic bacterial spores
Coliform Count	Total number of coliform bacteria colonies that have formed	Bulk milk samples are incubated on selective agar plates @30°C (or 37°C for E. coli) for 48h. After incubation the colonies of bacteria are counted visually or electronically	Not usually performed on bulk milk samples. <10 cfu/ml is considered good in the USA	AS 5013.5 Microbiology of food and animal feeding stuffs (see above)

** A colony can be formed from a single viable cell (a bacterium) which multiplies by binary fission. Colonies can also form from multiples of cells deposited together or from bacteria that normally grow in chains or clumps*

** cfu/ml - colony forming units per millilitre

ibc/ml - individual bacterial count per millilitre

Quality payment schemes

Every milk company has a scheme which specifies the parameters used to measure a dairy farm's supply of milk. The types of measures used, the thresholds applied, and the associated payments and penalties differ between companies. Below are some examples of quality payment schemes.

Table 3 Example 1 of a milk quality payment scheme

Quality test	Premium	Acceptable	Sub-standard	Unacceptable
Bactoscan (ibc/ml)	≤71,000	71,001–100,000	100,001–264,000	>264,000
BMCC (cells/ml)	≤250,000	250,001–400,000	400,001–600,000	>600,000
Thermoduric (cfu/ml)	≤2,000	2,001–5,000	5,001–10,000	>10,000
Inhibitory Substances/Residues	Negative	Negative	Negative	Positive

Table 4 Example 2 of a milk quality payment scheme

Quality parameter	Premium	Standard 1	Standard 2	Sub-standard
Bactoscan (ibc/ml)	≤80,000	>80,000–≤200,000	>200,000–≤400,000	>400,000
BMCC (cells/ml)	≤300,000	>300,000–≤400,000	>400,000–≤600,000	>600,000
Thermoduric (cfu/ml)	≤2,000	>2,000–≤5,000	>5,000–≤10,000	>10,000
Sediment	Disc 1 and Disc 2		Disc 3 and Disc 4	
Antibiotics (µg/ml)	Absent	>0.003		
Temperature (°C)	0–5	Milk >5 will be subject to a quality assessment		

Impacts on milk products

The quality of milk greatly affects its processing capabilities and the quality of the end products.

Poor quality milk can result in:

- the need for longer and more complex handling and processing procedures
- lower product yields
- increased wastage and costs
- reduced flexibility in the types of products that can be produced
- off-flavours in products
- discolouration of products
- shorter product shelf life
- inhibition or destruction of starter cultures
- reduced or restricted access to markets
- lower sale prices for products
- reduced customer demand
- negative customer feedback.

EQUIPMENT

Milking equipment

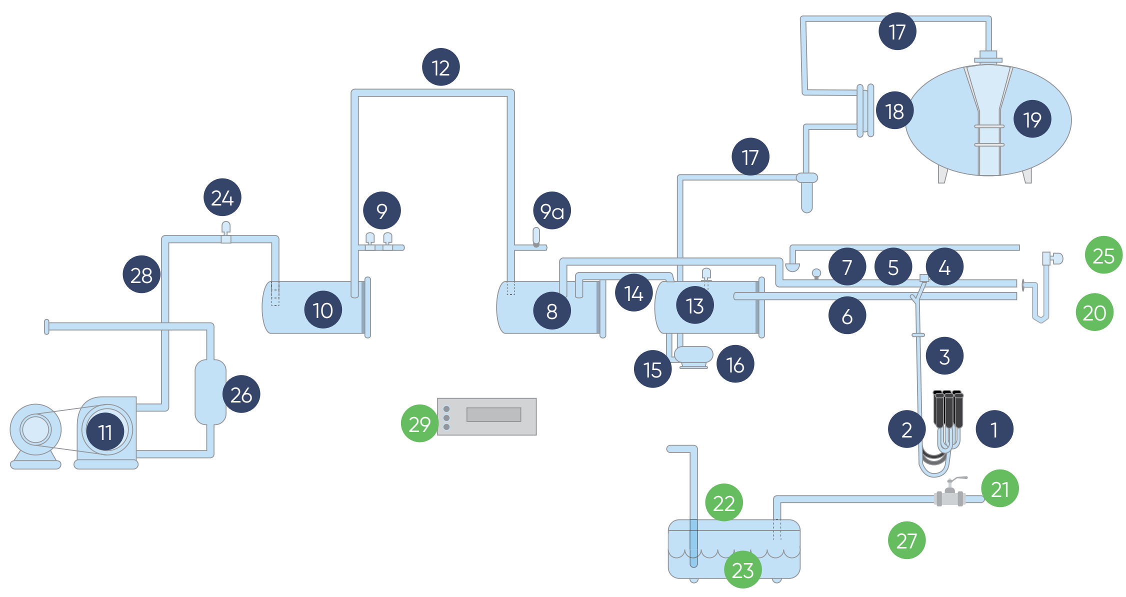
Cleaning components, function, performance

As milking machines become more complex, the task of assuring adequate circulation and mechanical cleaning action in all parts of the milking machine becomes increasingly challenging.

There are several components of a cleaning system that are connected to the milking machine in different locations **(Figure 3)**:

- Wash controller 29
- Wash tank 23
- Cluster cleaners/jetters 21, jetter lines 27 and wash manifold (not shown)
- Air injector 25, and water flush bend 20.

Figure 3 Milking machine schematic



1 Cluster
2 Long Milk Tube
3 Long Pulse Tube
4 Pulsator
5 Pulsator Alrline
6 Mllk Line
7 Vacuum Gauge
8 Sanitary Trap
9 Vacuum Regulator Meter
9a Vacuum Regulator Sensor
10 Interceptor
11 Vacuum Pump
12 Main Receiver Airline
13 Receiver
14 Receiver Airtine
15 Receiver Milk Pump Intake Line
16 Milk Pump
17 Delivery Line
18 Milk Cooler (Plate Heat Exchanger)
19 Bulk Milk Tank
20 Water Flush Bend
21 Cluster Cleaner/Jetter
22 Wash Return Line
23 Wash Tank
24 Vacuum Relief
25 Air Injector
26 Exhaust Muffler/ Oil Reclaimer
27 In-Place Cleaning Line/ Jetter Line
28 Main Airline
29 Wash Controller

Cleaning equipment

Milking units (clusters) are commonly attached to wash assemblies (called jetters/cluster cleaners), which are fed from a jetter line/in-place cleaning line. Cleaning solutions are drawn from the wash tank, via the wash manifold into the jetter line(s).

Wash controllers

A wash controller operates the wash system. Although the level of features and capability vary, nearly all controllers offer a selection of different wash programs which can be adjusted and fine-tuned to specific conditions. Controllers automatically dose the chemicals, manage the temperature of each cycle, and provide alerts and alarms when there are exceptions to a programmed sequence of events.

Wash tank

There are many types of wash tanks in use. The most common is a 205 litre dairy detergent container. One often overlooked element is the tank's thermal insulating properties. Minimising heat loss from the wash tank during cleaning improves cleaning effectiveness by helping to maintain thermal energy.

Figure 4 Automatic wash controller for milking machines (example only)

Figure 5 A semi-automatic wash controller for a bulk milk vat (example only)

Figure 6 Examples of different types of wash tanks

Jetters, jetter lines and wash manifolds

The clusters are connected to the jetters or cluster cleaners for cleaning. The mouthpiece of each liner must form a tight seal with the jetter for cleaning fluid to circulate through the cluster. Most jetters have adjustments to control flow rate. A flow rate of 3–5 L/min is considered sufficient for effective cleaning of clusters. Some jetter assemblies provide support for the cluster, reducing the stress on the mouthpiece to maintain the tight seal. This support also reduces the risk of mouthpiece distortion.

Figure 7 Two types of jetters: the one on the right provides support to the cluster

Figure 8 Wash manifold (example only). Cleaning solution uptake is manually controlled by using the lever valves.

Figure 9 Clusters attached to jetters mounted on the jetter line in the cleaning position (example only). Two different cluster orientations when attached to the jetters are shown

Air injector

An automatically controlled valve called an air injector admits air at pre-determined intervals to move cleaning solutions around the milk line.

Figure 10 Air injector and wash valve on a looped milk line (example only)

Cooling equipment

On most Australian dairy farms milk is cooled in two stages. The first stage involves pre-cooling which is typically performed using an in-line plate heat exchanger, also called a plate cooler. Milk is then cooled to 4ºC by the milk vat where it is stored until collection.

Pre-cooling of milk is essential for efficient and cost-effective cooling; most new bulk milk vats are now configured to rely on a pre-cooling system.

The current *Australian Standard AS1187–1996* for farm milk cooling and storage systems specifies the performance requirements for Australian conditions (see **Figure 13**). It emphasises that milk should be cooled to 4ºC within 3.5 hours from the start of milking.

An investigation by Tamplin, Ross and Rasmussen (2009) into the effectiveness of current Australian practices in cooling milk with respect to the viability of three types of bacteria identified the following three elements to have the greatest impact on growth potential:

- the time taken to milk a herd
- the exit temperature of the in-line cooler (plate cooler)
- the rate of cooling in the farm bulk milk vat.

This highlights the importance of cooling to control bacterial growth and the impact on milk quality. Cooling systems that fail to meet the performance specifications (as stated in the Standard) can compromise milk quality and can be a contributing factor in increased Bactoscan and thermoduric counts.

The performance of the cooling system should be evaluated — in relation to the current Australian Standard — when investigating a dairy hygiene problem.

MEASUREMENT OF PERFORMANCE

Reading milking machine test reports

Several results of performance measurements undertaken during a milking machine test provide important information on milking system's performance during cleaning. Results are recorded on a milking machine test report form; commonly the AMMTA milking machine test report form is used (**Figures 11** and **12**). The first two pages contain information relevant to equipment performance that can affect cleaning efficacy and dairy hygiene.

Figure 11 Front page of an AMMTA milking machine test report

AUSTRALIAN MILKING MACHINE TRADE ASSOCIATION
ABN 58 957 370 822
(Incorporated in Victoria)
Phone: 03 54 395 094

MILKING MACHINE TEST REPORT FORM
© Copyright AMMTA November 2009

Name: ....
Address: ....
Date: ....

MACHINE: Tested by .... AMMTA Mem. No. .... Qualification ....
Reason for Test .... Milkline Size & Configuration .... (mm) Dead end/loop
No of Units .... Minimum Line Fall ....% ....mm per metre
Dairy Type .... Pulsator Airline Size & Configuration .... (mm) Dead end/loop
No of Cows .... Regulator Type & Capacity ....
Last Herd B.M.C.C. .... Electric Motor HP/Kw .... Speed .... r.p.m.
Claw Type .... Motor Pulleys .... mm Section ....Shaft diam. ....mm
Liner type .... Vac. Pump Pulleys .... mm Section .... Shaft diam. ...... mm
Cup Dimensions .... (Length x O.D. x Hole) Vac. Pump Belts ....mm Section ....

MILKING MACHINE TEST SUMMARY & RECOMMENDATIONS

Mark box as ✓ = Satisfactory ✗ = Unsatisfactory (✗) = Most urgent service requirement

Milking machine performance test measurements **Recommendations**

- Pulsation system ☐
- Vacuum levels ☐
- Effective reserve ☐
- Cluster ☐
- Vac. Difference (WV/PIV1) ☐

Condition and/or suitability of main components

- Vacuum pump(s) ☐
- Pulleys & belts ☐
- Regulator ☐
- Vacuum Gauge ☐ ☐ High Vacuum Limiter
- Pipelines ☐
- Liners ☐
- Rubberware ☐
- Claw Tubes ☐
- Milk pump/Releaser ☐
- Air filters ☐ (Condition and cleaning frequency)
- A.C.R.'s ☐
- Other Components ☐

Safety

- Noise ☐ (8 hour decibel level measured in the working area. If excessive noise is suspected professional evaluation is recommended)
- Moving parts ☐
- Stationary parts ☐
- Electrical ☐

I acknowledge that I have read and understood the report and recommendations stated therein.

Signed: .... **Date: / / 20**

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Figure 12 Page two of an AMMTA milking machine test report

	✓	✗	Guidelines or specifications
1. **PULSATION CHARACTERISTICS - see over**			
2. **RELEASER/MILK PUMP:** Spit Chamber ❑ Diaphragm ❑ Centrifugal ❑			Max 25% dead time for S.C.R.
Inner flap open ___ B % Vac. (kPa) ___ ___			Min. Vacuum = 80 kPa/head (Diaphragm pump)
Outer flap open ___ D %			Between 30-50 str. min (Diaphragm pump)
Rate (c/min) ___ Str./min ___ ___			
3. **VACUUM LEVELS AND DIFFERENCES** (kPa) As found			
(a) Working Vacuum (WV) ___ - at central test point			High line 50 kPa max. — Difference between PIV1
(b) Regulator Vacuum level ___ - at regulator sensor point			Mid line 48 kPa max — and WV - prefer <2kPa
(c) Pump inlet vacuum (PIV1) ___ ___ - at the pump inlet			Low line 44 kPa max — - max 3.0 kPa
4. **REGULATOR OVERSHOOT/UNDERSHOOT** over ___ under ___ kPa			An overshoot or undershoot of less than 2 kPa is recommended
5, 6, 7 EFFECTIVE RESERVE, MANUAL RESERVE, AIR FLOW MEASUREMENTS			Min. Requirements .... L/min F
5. WV-2 Effective Reserve (ER) ___ L/min			**ER = 800 + 20n up to 40 units**
6. WV-2 Manual Reserve (MR) ___ L/min			**+ 10n for each unit over 40**
7. (a) Regulation efficiency % (ER÷MRx100) ___ %			Regulation efficiency must be 90% or greater
(b) Vacuum change at regulator or sensor ___ kPa (only measured if efficiency less than 90%)			Regulator should sense a minimum of 1.3 kPa drop when a vacuum drop of 2 kPa is applied at the CTP.
8a. HIGH VACUUM LIMITER / **8b. VACUUM GAUGE ACCURACY**			High vacuum limiter should be fitted between the vacuum pumps and the first high liquid level vacuum shut off point. Not recomended to be set above 55kPa
Fitted ___ ___ Y/N — @ 40kPa ___			
Operating ___ ___ Y/N — @ 45kPa ___			
Activation Level ___ ___ kPa — @ 50 kPa ___			Accurate within 2 kPa over range 40-50 kPa
9. **AIR CONSUMPTION OF COMPONENTS** — AFM Reading / Actual Value / Per Unit			
(a) WV Air consumption of components			
(b) WV Spit chamber releaser			Approx 20-40 L/min per end
(c) WV Pulsation			Approx 20-35 L/min/cluster
(d) WV Claw Air Admission			Spec: 4-12 L/min/cluster
(e) WV Ancilliary			
10. **AIR LEAKAGE**			**Not more than 10 L/min + 2 L/min/unit leakage into the milk system (milklines and receiver) and milk pump =**
(a) WV Milkline No. 1			**Calculated** ___ **Actual** ___
WV Milkline No. 2			Total system leakage shall not exceed 5% of Pump Capacity at PIV2 = ___ L/min
(b) WV Receiver			
(c) WV Pulsator Airline			Actual system leakage
(d) PIV2 Main/Rec. Airline			Total leakage measured in section 10 ___ L/min
11. **VACUUM PUMP** Make/Model ___ ___			P1 P2
Pump 1 / Pump 2			Rated ___ ___
(a) Pump inlet vac. (PIV2)			L/min - see manufacturer's specs.
(b) Speed ___ ___ rpm			
(c) Capacity @ 50kPa ___ ___ L/min/capacity			
(d) Capacity @ PIV2 ___ ___ L/min			**As a guide:** **Pump capacity = Required ER + 50 L/min/unit**
* Total Capacity @ PIV2 * (Same value into 10 (d) ___			___
12. **RECHECK WORKING VACUUM AND ER** ___ kPa ___ L/minF			
13. **VACUUM LEVEL MEASURED AT END OF**			
(a) Pulsator airline (not in rotary or looped line) ___ kPa			Within 2.0 kPa of WV
(b) Milkline or last cluster ___ kPa			
14. **REGULATOR SENSITIVITY** (vacuum at max. airflow through regulator) measured at the end of milkline or last cluster ___ kPa			Within 1.0 kPa of WW. Refer to test procedures in front of test book
15. **MILK SYSTEM LEAKAGE TEST COMPLETED** ___			Ensure no leaks into centrifugal milk pump
16. **DISINFECT TEAT PLUGS**			

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The key results to focus on:

Vacuum level (Working Vacuum)

- Is it appropriate to the equipment layout (see **Figures 13** and **14**)? If vacuum is too low, the ability to transport the cleaning solutions through the milking plant will be compromised.

Figure 13 The recorded Working Vacuum level is on page 2 of the AMMTA test report form

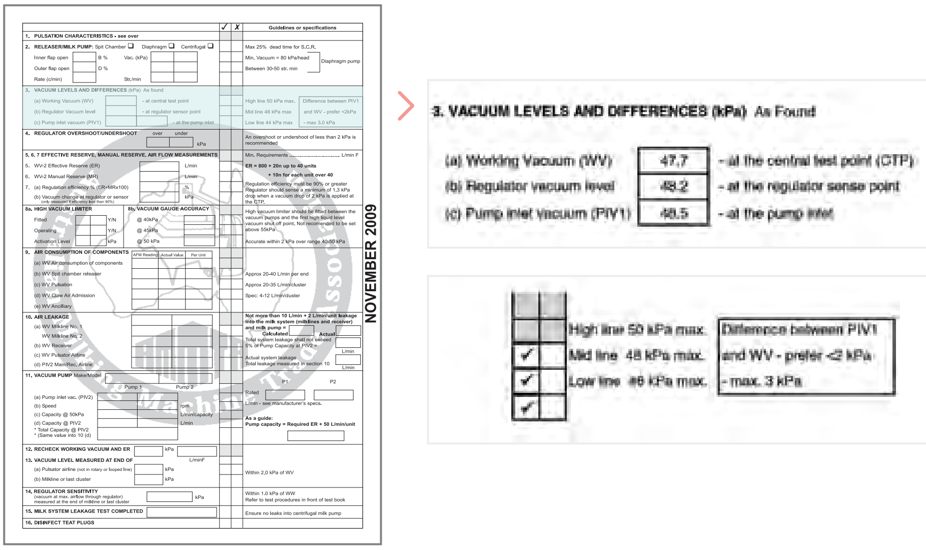
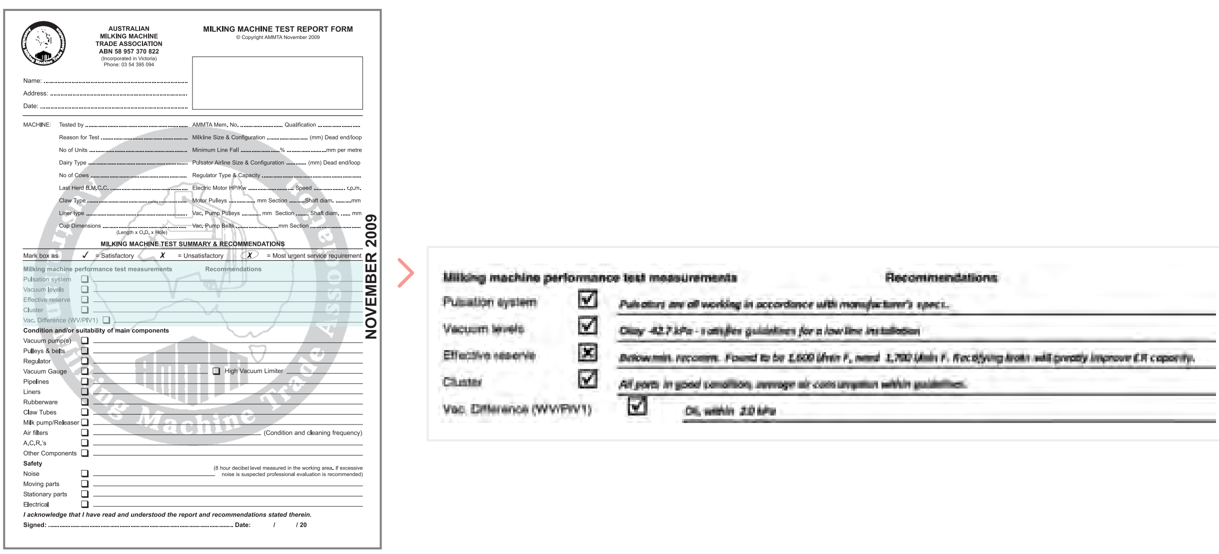


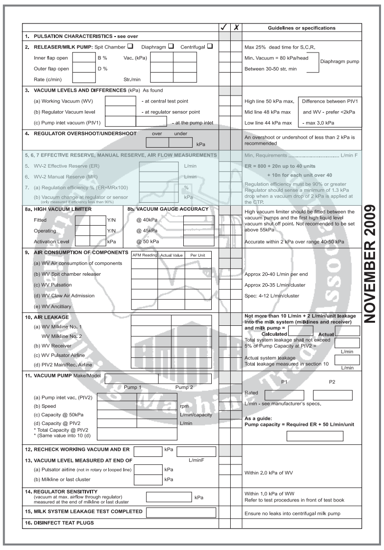
Figure 14 A summary of whether the vacuum levels and Effective Reserve capacity are appropriate is on Page 1 of the AMMTA test report form

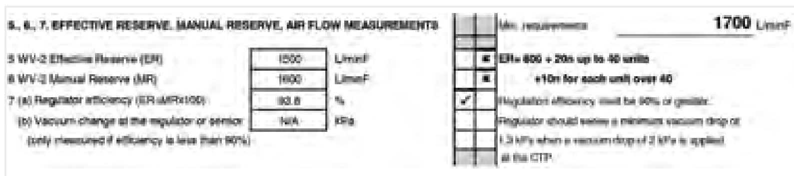


Effective reserve

- Does it meet minimum requirement **(Figures 14** and **15**)? If this is insufficient the ability to generate enough slugs (of cleaning solution along the milk line) of the required quality will be compromised.

Figure 15 The measured Effective Reserve capacity is shown on page 2 of the AMMTA test report form

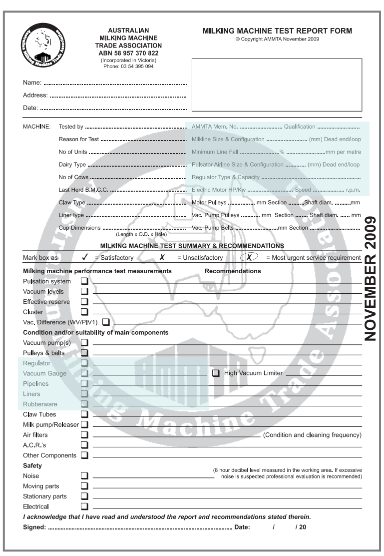




Milk line slope

- Is it within the recommended guidelines **(Figure 16**)? Adequate slope enables the plant to drain.

Figure 16 Details on whether the milk line has sufficient slope are provided on page 1 of the AMMTA test report form



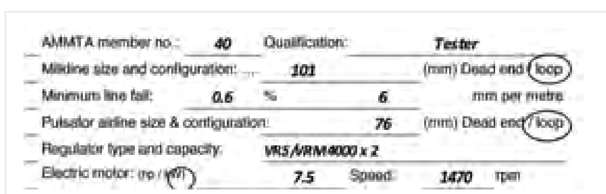
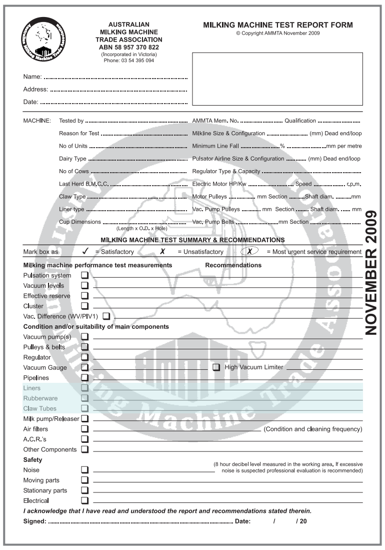
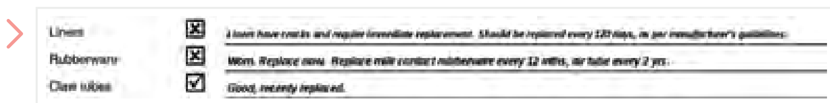


Figure 17 Details on the condition of rubberware are on page 1 of the AMMTA test report form. A visual inspection during a visit will often provide more up-to-date information





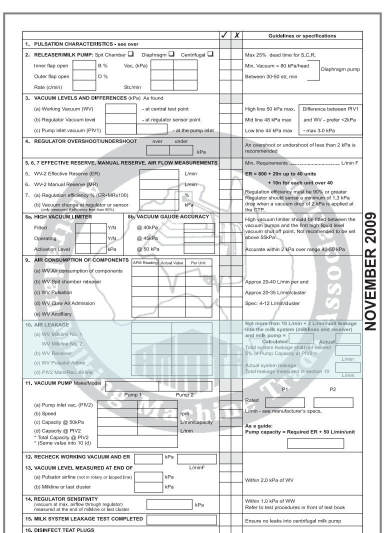
Condition of liners and rubberware

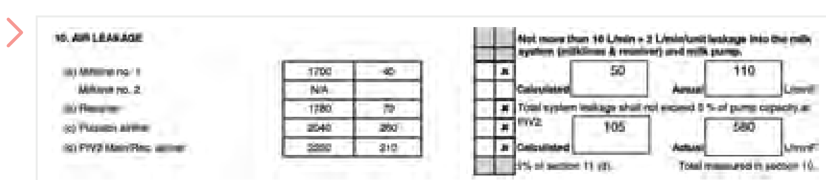
- Is it worn or past replacement time (**Figure 17**)? Old, worn and cracked rubberware is difficult to clean, and will harbour elevated levels of bacteria.

Air leaks in the milk section of the milking system

- Are they excessive (**Figure 18**)? Excessive air leaks in the milk line will compromise slug quality (of cleaning solution along the milk line). Air leaks also reduce the amount of available Effective Reserve.

Figure 18 Details on air leaks are provided on page 2 of the AMMTA test report form. A guide to maximum tolerable limits is provided on the right



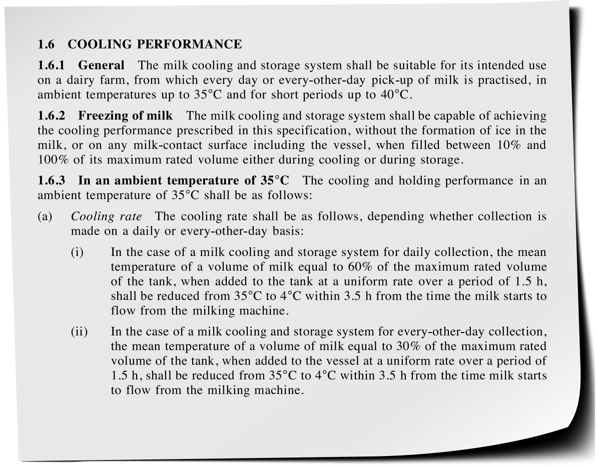


Cooling performance

Long cooling times, or milk that is continually being collected at temperatures above the 4ºC storage temperature are good indicators of poor performance. Poor performance can arise from a milk production system that has 'outgrown' the original design specifications (i.e. the farm's daily milk production exceeds the vat's cooling capacity), and/or there is a failure in the cooling. **Table 5** provides a list of items that can be checked to ensure the cooling system is working as intended.

AS1187–1996 is still the current Standard for cooling performance (**Figure 19**), however some dairy factories are promoting different performance criteria.

Figure 19 Bulk milk tank cooling performance requirements specified in the *Australian Standard AS1187–1996*



1.6 COOLING PERFORMANCE

1.6.1 General The milk cooling and storage system shall be suitable for its intended use on a dairy farm, from which every day or every-other-day pick-up of milk is practised, in ambient temperatures up to 35°C and for short periods up to 40°C.

1.6.2 Freezing of milk The milk cooling and storage system shall be capable of achieving the cooling performance prescribed in this specification, without the formation of ice in the milk, or on any milk-contact surface including the vessel, when filled between 10% and 100% of its maximum rated volume either during cooling or during storage.

1.6.3 In an ambient temperature of 35°C The cooling and holding performance in an ambient temperature of 35°C shall be as follows:

(a) *Cooling rate* The cooling rate shall be as follows, depending whether collection is made on a daily or every-other-day basis:

(i) In the case of a milk cooling and storage system for daily collection, the mean temperature of a volume of milk equal to 60% of the maximum rated volume of the tank, when added to the tank at a uniform rate over a period of 1.5 h, shall be reduced from 35°C to 4°C within 3.5 h from the time the milk starts to flow from the milking machine.

(ii) In the case of a milk cooling and storage system for every-other-day collection, the mean temperature of a volume of milk equal to 30% of the maximum rated volume of the tank, when added to the vessel at a uniform rate over a period of 1.5 h, shall be reduced from 35°C to 4°C within 3.5 h from the time milk starts to flow from the milking machine.

Table 5 Cooling equipment checklist

Check	Comment
Temperature of milk entering vat	The temperature of milk exiting an efficient plate cooler should be within 2ºC for an industrial plate cooler and 3ºC for a standard ('M' or 'P' series) of the incoming water.
Water flow rate	The ratio of flow rates between the water and milk is critical. A ratio of between 2:1 and 3:1 of water to milk is required. The specific design and size of the plate cooler will determine the best ratio, so refer to manufacturer's recommendations.
Correct sizing	The size (number of plates) of the plate cooler should be matched to the maximum flow rate of the milk pump(s).
Plate cleanliness	Contaminants from either the water or milk that adhere to the plates will affect their heat exchange capacity and reduce their performance.
Correct spacing between plates	If the gap between the end-plates is too small flow through the plate cooler will be impeded and performance can be compromised. Allow 2–3mm/plate (refer to manufacturer's specifications for further details).
Condenser cleanliness	Carefully brush the fins of the condenser unit to prevent build-up of dust and grime which reduces performance. Make this part of the (monthly) maintenance routine.
Servicing	Annual servicing by a refrigeration mechanic.

02

PRINCIPLES OF CLEANING

Principles of cleaning

PRINCIPLES OF CLEANING

Regardless of the techniques employed, or the layout of the milking equipment, there are six key elements that are fundamental to success in cleaning a milking machine. Whether it is a 'bucket milker' or a 100 unit fully automated dairy these basic principles of cleaning remain the same. The elements that underpin the principles of cleaning are tabled below.

Table 6 Principles of cleaning (adapted from Romney 1990)

Cleaning principle	Explanation
Soil	Milk based residues that deposit onto the surface of milking machine equipment. These residues contain organic (milk fat, protein, lactose) and inorganic (minerals) compounds. Microbial and water-borne contaminants can contribute to the deposit.
Water	Water quantity and water quality. Acts as the carrier of the cleaning chemical and the soil. Sufficient quantity and suitable (potable) quality are paramount for effective surface contact.
Energy	**Thermal energy** (temperature) provided by heating of water and wash solutions. It increases the diffusion of chemicals in a milk deposit, and increases the rate of chemical reactions. An increase of 10ºC doubles the rate of reaction of a cleaning solution breaking down a deposit. Temperature is also used as a sanitising agent. **Kinetic energy** (turbulence) primarily provided by the air injector (flushing pulsator) for cleaning the milk line and by cyclic movement of the liners to improve cleaning of the milking unit. Turbulence provides the scrubbing action in the cleaning process. The turbulent action creates shear forces to lift deposits from surfaces and also plays a dispersive role. **Chemical energy** drives the reactions between the detergent and the deposit. Reactions will occur if the chemicals are matched to the deposits. Universally, three types of dairy cleansers and sanitisers are employed to clean milk harvesting equipment: • Alkaline detergents: Used to remove the organic deposits, milk fats and proteins • Acid detergents: Used to remove the inorganic deposits, minerals • Acid/alkali based sanitisers: Primarily used to sanitise.
Time	Contact time between the cleaning solution and the surface to be cleaned.
Drainage	Ability of solutions and residues to be drained from the equipment, reducing contamination.
Equipment maintenance	Routine maintenance of milking machine components and system performance.

Soil

The 'soil' in milking machines derives mainly from a build-up of milk based residues. Milk is a complex product containing many compounds that are chemically dissimilar. Milk's high nutrient value makes it an excellent medium for bacterial growth. A build-up of milk deposits enables bacterial growth to occur.

Soil may also include mineral deposits (mainly from water), chemical residues (from treatments, such as antibiotics or teat sprays), and organic matter (from the cows' teats).

Milk, milk residues and deposits

The composition of milk residue can change over time. As water evaporates and carbohydrates are 'lost' the relative composition of the residue will change. **Table 7** shows the relative composition of milk's components as it forms a deposit.

Table 7 Composition of milk and milk residues

Milk component	% in milk	% in newly formed deposit	% in milkstone
Water	87	20	3
Fat	4	25	3–18
Protein	3	20	4–44
Carbohydrates (lactose)	5	25	0
Minerals	4	10	42–87

Source: DeLaval

Considering the chemical complexity of milk, failure to follow a specific cleaning routine may allow residues to build up within a milking machine very quickly. Such residues may be extremely difficult to remove.

The different properties of the components of milk and milk deposits, i.e. protein, fats, minerals, and lactose necessitate separate use of both acid and alkaline detergents.

Milk proteins

Milk protein accounts for 3–4% by weight of fresh milk. Milk proteins are divided according to their physical characteristics into two types:

- **Casein** – 80% of total protein
- **Whey –** 20% of total protein

Protein in milk serves as a source of nutrition. It also enables milk to exist as an emulsion by forming an envelope around the fat, preventing it from separating in the milk. The membrane proteins are able to do this because they are soluble in both the fat and water components of milk.

When leaving the cow at 37ºC the fat globule and protein membrane are in the liquid phase and can easily change shape when exposed to moderate mechanical treatment. Thus flowing through pipes and pumping action will not result in damage to the membrane. However, as the milk temperature lowers the membrane become more susceptible to damage. If the membrane is damaged fat will become susceptible to breakdown by the enzyme lipase into free fatty acids and glycerol. This fat breakdown is known as lipolysis. Lipolysis is not desirable as free fatty acids contribute to the rancid flavours in milk.

As damaged milk passes through the milking machine some free protein and fatty acids adhere to the machine surfaces.

Casein

Casein proteins are large polymers containing thousands of individual molecules. These proteins are very complex and chemically reactive.

Casein may be precipitated (settled) from solution with metallic salts such as magnesium or calcium. This is a common occurrence where bore water that is 'hard', i.e. high in metallic salts, is used for rinsing milk residues from milking equipment. The resulting deposit is difficult to dissolve as it is very stable. It is light brown in colour and slimy in texture when wet. It has little odour and may be only removed with very strong alkaline solutions.

Whey

These proteins will not precipitate from the addition of metallic salts or at temperatures less than 60ºC. However, if milk is heated to over 60ºC some of the whey proteins denature and form complexes with casein. The process is known as crosslinking and is commonly described as 'cooked' or baked-on milk.

During the hot wash when there is much less milk in the machine a small amount of crosslinking may occur. However, the benefits of high temperature washing outweigh any problems associated with crosslinking. Thus, the payoffs from washing at a temperature of approximately 75ºC, which is just above the optimal temperature (>70ºC) for milk fat removal , outweigh the costs associated with crosslinking. At temperatures greater than 85ºC this advantage is lost. To achieve a wash temperature of 75ºC at the claw water should be approximately 85ºC at the wash trough.

Table 8 Principal fatty acids in milk fat (Tetrapak, 1995)

Fat type	Name	% Milk composition	Fat melting temperature (ºC)
Saturated fats			
C-4	Butyric acid	3.0–4.5%	-7.9
C-6	Caproic acid	1.3–2.2%	-1.5
C-8	Caprylic acid	0.8–2.5%	16.0
C-10	Capric acid	1.8–3.8%	31.4
C-12	Lauric acid	2.0–5.0%	43.6
C-14	Myristic acid	7.0–11.0%	53.8
C-16	Palmitic acid	25.0–29.0%	62.6
C-18	Stearic acid	7.0–13.0%	69.3
Unsaturated fats			
C-18	Oleic acid	30.0–40.0%	14.0
C-18	Linoleic acid	2.0–3.0%	-5.0
C-18	Linolenic acid	up to 1.0%	-5.0
C-20	Arachidonic acid	up to 1.0%	-49.5

Milk fats

Milk fat accounts for approximately 4% by weight of cows' milk and exists as small globules dispersed in the milk serum. The diameters of the globules range from 0.1 to 20 µ and they consist mainly of triglycerides and many other fat soluble substances encapsulated in a thin protein coat.

Milk fat is divided into two groups; saturated and unsaturated fats. Each group is further divided into fractions that have different melting points (**Table 8**). Each fatty acid has a carbon number which is written as C-#. As the carbon number increases for saturated fats, the melting temperature of the fat increases and its solubility in water decreases.

Fatty acids are not soluble in water but can be made soluble by the action of an alkaline detergent.

This process is known as saponification (See Appendix 1, for a summary of the chemical compounds involved in this process). The process of saponification explains why it is possible to remove milk fat from installations at temperatures below its melting point.

Milk Minerals

Milk contains all of the minerals essential for calf nutrition, with the exception of iron. The major cow milk minerals include calcium, phosphorus, sodium, potassium, magnesium, and chloride. However, it is mainly the cleaning water mineral which dictates the acid usage for the wash program, rather than that in the milk. Water may contain calcium, magnesium, iron, manganese and other minerals that can negatively affect the performance of cleaning compounds.

A typical example of an acid dissolving a mineral deposit is when acid is added to a lime deposit.

The minerals dissolve, and the process gives off gas and water (see Appendix 1).

Lactose

Lactose is the primary milk carbohydrate (sugar). It is water soluble, readily dissolved in weak acid or alkali solutions, and poses no major cleaning challenges.

Water

Dairy farmers around the world contend with a vast range of conditions and water sources.

Water quantity and quality characteristics, often limited by availability and cost are a prime consideration when choosing a dairy hygiene program.

Water quantity

For successful cleaning it is important to ensure all milking components to be cleaned are in contact with adequate cleaning solution volumes (quantity) and for sufficient time. This balance between contact time and volume is often given insufficient consideration resulting in ineffective cleaning.

Each cycle of the wash program plays a different role but all require the correct quantity of water to be effective. The volume of water required to successfully undertake each cycle depends on several considerations: the types of dairy chemicals used, the cleaning method deployed, and size of the equipment to be cleaned.

Milking machines

The method in **Table 9** can be used to determine the minimum water volume required per wash cycle for effective flow dynamics in air-injected milking machine cleaning systems. The total volume can be then used to size wash tanks in new systems or to check if the actual water used per cycle meets the minimum requirement.

Table 9 Method for determining the minimum volume required per cycle for a milking machine that has an air injector system (adapted from Reinemann and Wolters 2002)

	Line diameter	Multiplier	Litres of water
Metres of milkline			
	98mm	1.50	
	73mm	0.84	
	60mm	0.57	
	48mm	0.36	
Metres of wash and milk delivery line			
	73mm	4.2	
	60mm	2.8	
	48mm	1.8	
Receiver(s) volume	**Litres**		
		0.33	
Number of milking units	**Units**		
		1	
Number of milk meters	**Meters**		
		1	
Metres of milk hose	**Hose diameter**		
	14mm	0.15	
	16mm	0.20	
Number of plate coolers	**Plate coolers**		
		8	
Total (Litres)			

Another, and perhaps simpler way, to estimate the water quantity required to achieve adequate surface contact and minimise thermal loss is to use a guide based on the experience of Australian-installed milking systems. This guide uses the number of milking units to calculate the volume of each cycle. It suggests an average cycle volume of 6–8 L/unit; with 6 L/unit for small milking machines (up to 20 milking units) and 8 L/unit for larger milking machines (20 units and over). An average cycle volume value is given because some wash programs specify a higher cycle volume (e.g. 10 L/unit) for the first pre-rinse cycle but a lower cycle volume (e.g. 5 L/unit) for the subsequent cycles. Cycle volumes will need adjustment to accommodate individual circumstances, such as long milk delivery lines, and cleanser/sanitiser label directions. A guide to the minimum required cycle volumes is shown in **Table 10**.

A practical way to confirm sufficient cycle volume is to observe a recirculated cleaning cycle. When wash water is recirculated the minimum volume required is equal to the volume needed to maintain recirculation without the water pick up pipe admitting air.

Table 10 Industry guide for estimating the minimum volume of water per cycle for effective cleaning of a milking machine

No. units	Volume of water per cycle (Litres)
20	160
25	200
30	240
40	320
50	400
60	480

Bulk milk tanks

Determining the actual volume used in each cycle in a vat with a modern automated cleaning system often requires consultation with the specifications provided in the technical manuals. As a general estimate, the total volume of water required to wash a milk vat is around 5% of the vat's capacity, depending on the level of cleaning automation and wash program selected. Some vats can require as little as 3% of their capacity to complete a wash.

Table 11 Guide to the amount of water required for different vat capacities

Vat capacity (Litres)	Volume of water per wash* (Litres)
6,000	180–300
10,000	300–500
16,000	480–800
20,000	600–1,000
24,000	720–1,200
30,000	900–1,500

**Guide only. Water use varies according to wash program selected, vat design and cleaning system design.*

Hot water requirements

For the milking machine or the bulk milk vat the volume of hot water required is dependent on the wash program selected. And of course, selecting an appropriate wash program will depend on hot water availability. The easiest way to estimate the quantity of hot water required is to first establish the cycle volume. The cycle volume is then used as the basis for estimating to water requirements – both hot and cold (**Table 12**).

Table 12 Example of estimating the volume of hot and cold water required for a wash program

Cycle	Cycle type	Cycle volume	Temperature	Cold (Litres)	Hot (Litres)
1	Pre-rinse	400	Warm (38°C)	300	100
2	Wash	400	Hot	0	400
3	Sanitising rinse	400	Hot	0	400
Total		**1,200**		**300**	**900**

For a warm 38°C cycle ~25% of hot (90°C) and 75% cold (ambient, 20°C) water is required.
In this example, 1,200 litres of water is required per wash.

Water quality

Unlike many other dairying countries, water quality poses the greatest challenge to cleaning in Australia.

It is generally poor and can be highly variable, even from the same source. The best quality water should be used for cleaning the milking machine and milk vat. It should be potable water – suitable for human consumption (**Figure 20**). Two commonly used indicators of water quality are hardness content and microbial contamination. Suspended solids, organic matter, chemicals, and odours are other indicators of water quality.

Figure 20 The quality of water required for different cleaning applications

Water quality	Cleaning application
Good water quality (Rain/town water)	Staff facilities Milking machine Milk vat
	Test buckets etc.
	Teat washing
	Milk pre-cooling
Poor water quality (Effluent water from second pond)	Shed washing
	Yard washing

Water hardness

Hardness is determined by the mineral content present in the water. Calcium (Ca) and magnesium (Mg) in the form of carbonates are the two most prevalent minerals. Iron (Fe) is another mineral that is often found in elevated levels in many dairy farm water supplies.

In Australia a commonly used measure of water hardness is total hardness and is expressed as mg/L or ppm of calcium carbonate ($CaCO_3$). An example of different classifications of water hardness is given in **Table 13**. The softer the water is the better its quality and the greater its range of uses.

The harder the water is, the less suited it is for cleaning. Hard water means:

- more chemicals are needed to compensate for reduced cleaning action
- more complex alkaline detergents are required – those containing sequestering and chelating agents
- more frequent use of acid based detergents to dissolve the minerals and prevent build-up on equipment
- more corrosion of hot water heating elements and other milking equipment.

Table 13 Water hardness classifications

Classification	$CaCO_3$ (mg/L*)
Soft	0–50
Moderately soft	50–100
Slightly hard	100–150
Moderately hard	150–200
Hard	200–450
Very hard	450–700
Extremely hard	>700

**1 mg/L = 1 ppm* $CaCO_3$

Hard water is sometimes described as either 'temporary' or 'permanent' depending on which ions it contains. When temporary hard water is heated, calcium carbonate and/or magnesium carbonate precipitate(s). The resulting deposits can eventually lead to destruction of the heating element (See Appendix 1). To protect the hot water system from temporary hardness, water should be softened or an alternative water source found. Nowadays many dairy hot water systems contain 'sacrificial anodes' to help protect against hard water. The ions in the hard water 'attack' these sacrificial anodes instead of the hot water system. They need to be regularly checked and replaced before they are completely corroded.

Wash programs must be adjusted to compensate for the effect of hard water:

- more alkaline detergent must be used to clean milk residues from the milking machine
- detergents used in hard water should include **sequestering** or **chelating** agents. These prevent scum formation and other forms of hard water precipitation by preventing the alkaline part of a detergent from reacting with the hardness ions and precipitating on to the internal surfaces of the milking machine.

  For example, tripolyphosphate combines with the hardness ions and keeps them in solution (See Appendix 1), allowing the detergent to react with milk fat (**saponification**) and milk proteins.
- acid detergent should be used more frequently to assist in the removal of hard water scale.

Green Cleaning Systems require water with a hardness of less than 150ppm ($CaCO_3$) and an iron level of less than 0.5ppm.

Iron in water

The iron content of water must be taken into account when selecting detergent programs for cleaning dairy equipment. Iron can be present in water in a number of forms; soluble iron, which cannot be seen and insoluble iron, which precipitates out of the water. The presence of iron radically reduces the effectiveness of alkaline detergents. It is also the main food source for 'iron-loving' bacteria. Iron will stain equipment at concentrations as low as 0.3ppm. If the iron content of rinse or wash water is high, the wash program should be adjusted to include more frequent use of acid detergents.

Water source

Hardness can vary between sources and from the same source at different times of the year. If the water is found to be hard, then commercially available water softening systems should be incorporated, if an alternate better quality water supply is unavailable.

Water used in a dairy may come from very different sources. When designing a dairy wash program, it is prudent to assume that the water, regardless of its source, may have microbes present. Only the water from the hot water cylinder (if it is working correctly i.e. > 90ºC) should be considered microbe free.

Suspended solids and organic matter

Water containing suspended solids and/or organic matter can dramatically reduce cleaning performance and effectiveness. Often detergents with greater dissolving, emulsifying, and dispersing capacities are needed to counteract the impact of 'dirty' water. Furthermore, chlorinated detergents (and sanitisers) can be deactivated when the water contains organic matter.

Energy

The energy required to remove soil from a milking machine is equal to the sum of the forces of attraction between the surface (substrate) and the soil, plus the energy required to transport the soil washed from the cleaned surface. The forces of attraction are related to the physical and chemical nature of both the soil and the surface.

During the cleaning cycle energy is applied to the soil in three basic forms:

- **Thermal energy:** in wash water temperature
- **Kinetic energy:** in the form of wash solution turbulence
- **Chemical energy:** the chemical reaction between the detergent components and the soil.

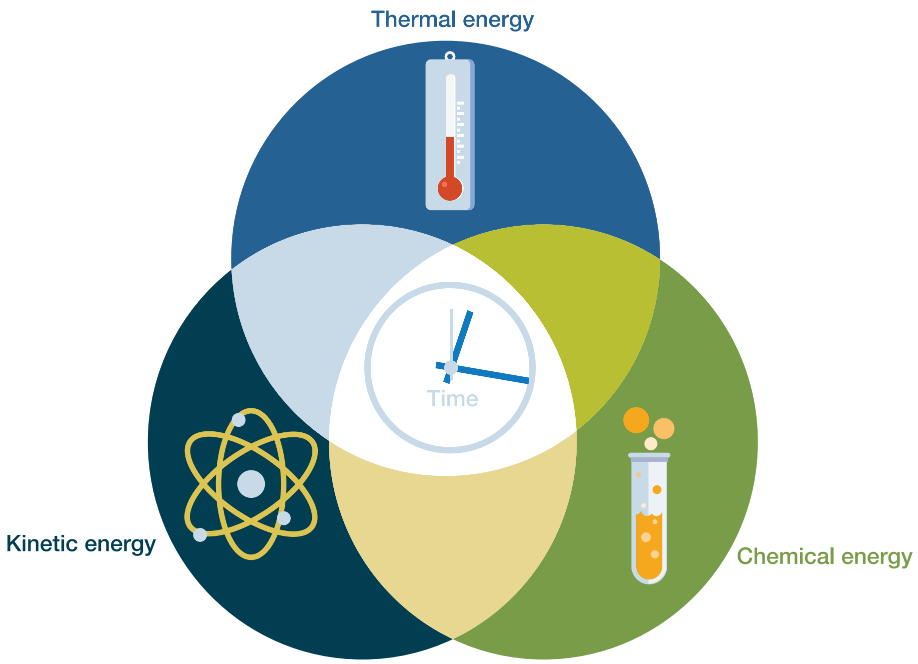
A fourth form of energy, known as surface activity, is sometimes referred to but will not be covered in this handbook in any great depth. However, it should be noted that surface active agents are very important in the formulation of detergents. Their role is to absorb into the soil and substrate, lower the surface tension, and thus encourage the penetration of the soil deposits by the detergent solution. In this handbook surface activity is included as chemical energy although strictly speaking it is a physical process (Romney 1990).

Any process, whether physical or chemical, requires time to complete. The relationship between time and these forms of energy is illustrated in **Figure 21.** All four elements must be present; they make up the cleaning cycle.

If any element is reduced, then the other elements need to be increased to compensate for the deficiency.

Note: it is generally accepted that a deficiency in any one energy component can only be partially compensated for by an increase in the others. All three forms of energy are vital for successful cleaning.

Figure 21 The three basic forms of energy combine with time make up the cleaning cycle



The basic process of soil removal

The basic process of soil removal is as follows:

1. The soil is lifted when energy overcomes the forces of attraction between the soil and the substrate
2. The soil is dispersed in the wash solution
3. The soil is rinsed clear of the substrate without any re-deposition.

The energy transferred from the wash solution to the soil does the work; work is done whenever energy is transferred from one object to another. The rate of energy transfer is known as power.

For example: If a worker can move 1 tonne of sand 1 metre in 60 minutes, the power output can be described as 1 tonne/metre/hour. Notice that if the worker is only allowed 10 min. then the amount of sand that can be moved at this level of power output is equal to 0.17 tonne (i.e. 1 tonne/metre/hour x 10/60). The only way of moving more sand in 10 minutes is to increase the rate of energy transfer, that is, increase the power output.

The energy/time relationship holds true with respect to soil removal. For example, a surface requires a wash solution to be in contact with it for 5 minutes under a particular set of energy conditions (turbulence, temperature, and chemical) to remove all traces of soil. What happens if the time is reduced to two minutes?

The answer is simple. The rate of energy transfer must be increased or the surface will not be cleaned. This rate of energy transfer can be increased through increasing the amount of energy (chemical, kinetic, and/or thermal) in the wash solution.

Thermal energy

Thermal energy is vital for an efficient cleaning system. Hot water melts fat and increases the reactivity of detergents by a factor of 1.5–2.0 for every 10ºC increase. Hot water and detergent provide the energy required for the dispersion and removal of milk residues from soiled surfaces. As the temperature falls the detergent itself must provide the energy to hold the milk residues in solution. In most cases this is very difficult and as the wash water is allowed to cool further, the energy available in the solution will not be enough to maintain the residues in solution. To prevent re-deposition of soil wash water should be discarded at or above 60ºC (see the temperature guidelines below). Re-deposition often occurs when recirculation is allowed to continue for too long.

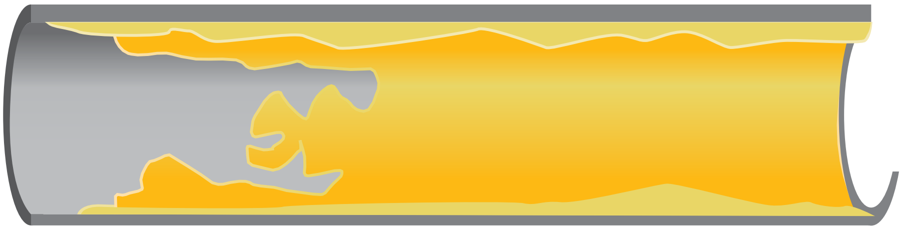
Proteins and temperature

If the first rinse after milking, when there is the most milk residue in the milking machine, exceeds 60ºC, then crosslinking of proteins can occur (see Whey on page 20) and the residue can be 'baked' onto the surface of the equipment (**Figure 22**).

Fats and temperature

At 60ºC almost 60% of the milk fat has melted (see **Table 8**). At 700ºC all the milk fat is in a melted form, making it much easier to remove from the milking equipment. The process of saponification (see Appendix 1) explains why it is possible to remove milk fat from installations at temperatures below its melting point.

Figure 22 Proteins baked on to the surface when the rinse temperature exceeds 60ºC



Fats, proteins, and cleaning temperature

Detergents formulated for use in hot water will have an optimum temperature range for effective cleaning performance (**Figure 24**). This is usually stated on the detergent's label. An optimal cleaning temperature for many detergents used in Australia is between 60ºC and 70–75ºC (see **Figure 23**). This should not be confused with the temperature of the water at the start of the wash cycle, which is often stated as 'hot' or '85ºC'. The higher start temperature is usually stated to allow for temperature losses as the wash solution is drawn through the milking machine. A starting temperature of 85ºC will often result a temperature of around 75ºC inside the milking system (e.g. inside the claw bowl). It is important to recognise that the temperatures achieved during cleaning will be influenced by many factors, such as:

- starting temperature
- ambient temperature
- preceding cycle temperature and the expired time between cycles
- cycle volume
- water flow rate through the equipment
- contact time
- size of equipment and distances (pipe lengths etc.)
- air admission (planned and unplanned)
- mass of metal components to be heated to an equilibrium temperature by the cleaning solution.

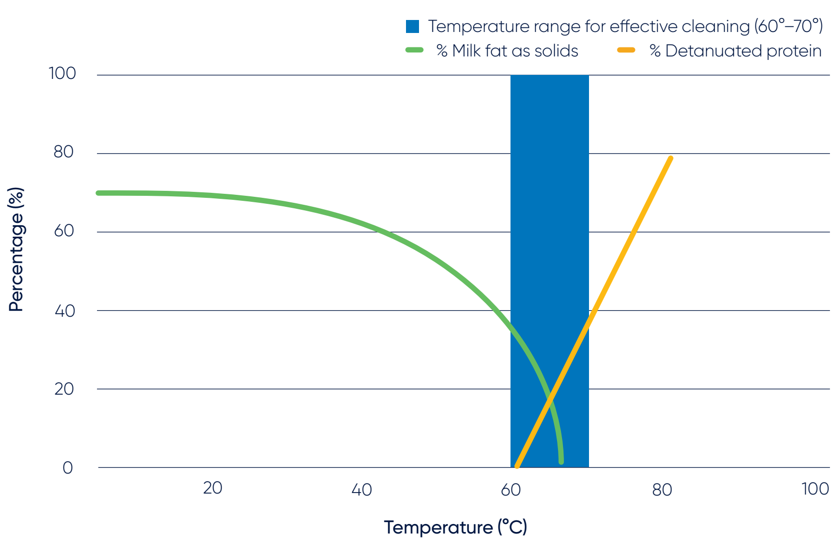
Figure 23 Examples of label directions specifying the temperature for optimal detergent performance

DIRECTIONS FOR USE
1. Arrange C.I.P. milk lines so that wash solution can be recirculated.
2. Immediately after milking, rinse milking machine using **"DeLaval Preclean"** solution at 35°C.
3. Wash plant using a minimum of 7L of how wat water per cluster. Add 15 to 20g of **"DeLaval Preclean"** per 10L of hot water. For best results, wash solution must be 80–85°C at the wash tub. Circulate wash solution for a maximum of 5 minutes or until the wash solution temperature drops to 60°C, whichever occurs first.
4. Rinse milking machine immediately with hot clean water.
5. For best results, **"DeLaval Chlortech"** should be used as part of a program including DeLaval's acid detergent **"DeLaval Acidsan Low Foam"**.

DIRECTIONS FOR USE
DIRECTIONS – MILKING MACHINES – EVENING ALKALI CLEANING
1. AFTER MILKING RINSE PLANT USING ALKA RINSE AS PER LABEL DIRECTIONS WITH COLD WATER (20°C–30°C) USE 10 LITRES PER UNIT.
2. Use REV–WASH detergent at the rate of 40ml per 10 litres of hot water (60°C). Use a minimum of 10 litres per set of cups.
3. Use a rinse of very hot water (80°C) to complete the cleaning program.

NOT TO BE USED FOR ANY PURPOSE, OR IN ANY MANNER, CONTRARY TO THIS LABEL UNLESS AUTHORISED UNDER APPROPRIATE LEGISLATION.

Figure 24 Temperature range for effective cleaning



Kinetic energy (turbulence)

Waterflow in a pipe can be described as either 'laminar' or 'turbulent'. Flow characteristics are determined by a number of factors including pipe diameter, solution temperature and flow rate. Laminar flow is where layers of liquid slide over one another without any flow across the boundaries. Under these flow conditions the friction at the pipe surface is minimal. As the flow rate increases the water will change its flow characteristics from stratified to a critical point where intermingling of layers starts to occur.

Beyond this point, the flow becomes turbulent and friction at the pipe surfaces increases dramatically. This increase in friction (scrubbing action) between the pipe surface and the wash solution is highly desirable from a cleaning point of view.

Turbulent flow conditions are essential for the effective cleaning of a milk line. *Interestingly, laminar flow conditions are ideal for milking.*

For many years, a flow velocity of 1.5 m/s was considered adequate to achieve turbulence regardless of pipe diameter. This simplistic approach means a 50mm milk line requires a flow rate of 177 L/min to create turbulence, and a 100mm milk line requires a flow rate of approximately 707 L/min! These flow rates are almost impossible to achieve, so as an alternative approach, milking machine systems use air injection to create adequate turbulent conditions.

An air injector (flushing pulsator), set correctly, will create the necessary 'slugging' action to clean the milk line and receiver vessel.

A 'slug' (a fast moving plug of water) is created when a large volume of air is admitted into the milk line behind a set volume of wash water. The rate of air admission determines the slug velocity whereas the time setting between air admissions determines slug **volume**. The aim is to have 12–15 well-formed slugs entering the receiver during the wash cycle, at a **velocity** of between 7 and 10 m/s. Slugging action can be assessed by visual inspection during washing and by taking measurements of slug velocities (see page 56).

Chemical energy

The reactions between the soil and the detergent are caused by chemical energy. These reactions are desirable because they tend to increase the solubility of the soil, reducing the overall energy requirement to clean. However, this is only true if the detergent is correctly matched to the soil. For example, alkaline detergent will not remove a limestone deposit whereas an acid will.

The physical/chemical properties of the soil also determine the optimal temperature for the reactions to occur. Generally, temperatures above the melting point of milk fat are necessary where milk-based soils are to be removed (see **Table 8** on page 21). The rate of chemical activity is increased by increased temperature (refer to Thermal energy on page 27).

A well formulated detergent will have agents that contribute one or more desirable cleaning characteristics. The main cleaning objective is to remove the soil and leave the surface free of all soil and foreign matter. To achieve this goal, detergents should have the following properties:

1. **Wetting action:** To penetrate the soil so the wash solution can contact all surfaces including the substrate.
2. **Dissolving and chemical reactivity:** To bring the soil into solution.
3. **Emulsification and dispersion:** To suspend soil in the wash solution.
4. **Water softening:** To prevent the loss of alkalinity of the cleaning solution and to reduce scale and scum formation.
5. **Rinsability:** To ensure removal of both soil and the cleaning compound.
6. **Disinfecting properties:** To clean and disinfect. The chlorine in chlorinated alkalis acts to breakup protein deposits as well as kill microbes. Many different types of chemicals can be used to kill microbes.

Figure 25 A well-formed slug in the milk line

Acid and alkaline detergents, and pH

The most commonly used detergents in the dairy industry fall into two groups: acids and alkalis.

Acid detergents provide the chemical energy to dissolve mainly mineral based deposits.

Alkaline detergents provide the chemical energy to dissolve organic (fats and protein) based deposits.

The main difference between acid and alkaline detergents is their pH values. The pH value indicates the concentration of hydrogen ions in a solution. The chemical power of a detergent is indicated by its pH. The pH scale is a logarithmic scale, so a pH of 4.0 is 10 times as acid (contains 10 times more hydrogen ions) as a pH of 5.0. Also, a pH of 13 is 10 times more alkaline than a pH of 12 (see below). The pH of a solution is easily determined by using indicator paper or a pH meter.

Acid detergents

Acid detergents are formulated to provide the optimal pH for removing scale and mineral deposits.

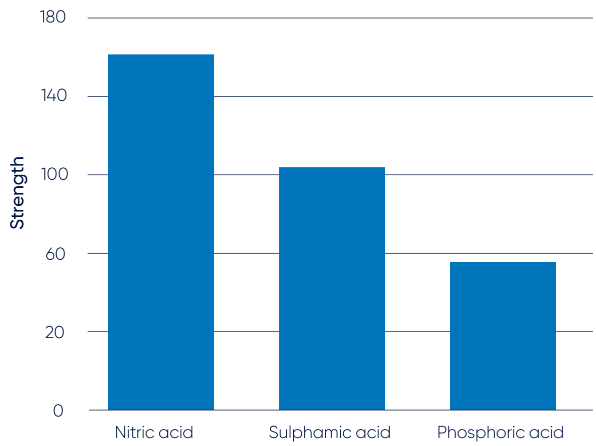
A low pH also makes it more difficult for bacteria to grow.

For an acid wash solution, the pH should be between 2.5 and 3.5.

Acid detergents are not affected by hard water, therefore, the label dose rate should, in principle, always guarantee a pH within this range. This however, will not be accurate if the water pH is too alkali. Depending on the pH of the water supply and its buffer capacity (ability to resist pH change), a higher acid dose may be needed.

An acid works by releasing hydrogen ions in solution. Some acids are much more efficient at releasing these ions and are consequently stronger (**Figure 27**). Therefore, one can't say that a product is stronger simply by reading the concentration level on a label. The type of acid and its concentration dictate the relative efficacy: at the same acid concentration, the lower the pH the stronger the acid. Similarly, for alkalis; the higher the pH for equal concentrations, the stronger the alkali.

Figure 27 Relative strengths of three different acids



Nitric acid: H-O-NO_2

Sulphamic acid: H-O-SO2-NH_2

Phosphoric acid: $(H-O)_3$-PO

Please note that nitric acid is included here for illustration but is not recommended for use in cleaning milk harvesting equipment without adequate rinsing as it can be corrosive on stainless steel.

Figure 26 The pH scale showing the required range for acid-based and alkali-based dairy detergents

pH														
			Acid detergents								Alkali detergents			
0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Strong acid					Neutral					Strong alkali				

Alkali detergents

Alkali detergents are affected by hard water, therefore, dose rate adjustments will be required to guarantee optimal active alkalinity, pH, and chlorine level.

Active alkalinity (sometimes referred to as AA) is a direct measure of the alkaline concentration of a given solution. It is determined by titrating an acid of known concentration against a fixed volume of alkaline wash solution.

The desired level of active alkalinity is affected by the soil load. The heavier the soil load (either from the water or the residues in the equipment) the higher the active alkalinity should be for the detergent to perform correctly. This is achieved by increasing the dose rate and/or selecting a detergent better formulated to cope with heavier soil conditions.

Table 14 outlines active alkalinity levels under various soil loads in ideal (turbulence, time, and temperature) cleaning conditions.

Table 14 Guideline for levels of active alkalinity based on soil loads

Soil load conditions	Example	Active Alkalinity (ppm)
Light	Small dairies (<13 units) with small pipelines (<63mm diameter), and short milking times (<1.5 h). Practice good milking hygiene.	800
Medium	Medium-sized dairies (<25 units), and medium milking times (<2h). Practice good milking hygiene.	1,000
Heavy	Large dairies, large diameter pipelines, longer milking times, or practice 'average' (no teat preparation) milking hygiene.	20

To compensate for conditions where wash temperatures are lower, such as for bulk milk tanks, the active alkalinity must be increased. An active alkalinity of 2,000 to 3,000 is recommended.

For a wash solution containing a chlorinated alkaline detergent the pH must be between 11.5 and 12.5. For one containing a non-chlorinated alkaline detergent the pH must be at least 12.

Chlorine, when formulated into alkaline detergents at sufficient concentrations, can have a disinfecting quality by facilitating the removal of biofilms (Sundberg et al. 2011). For chlorinated alkaline detergents, the minimum chlorine levels (measured as available chlorine) should not be less than 70ppm. For sufficient bactericidal activity, a minimum of 100ppm is required.

Sanitisers

Sanitisers are formulated to kill microbes. There are many types of sanitisers registered for use in the Australian market. They can be chlorinated or non-chlorinated; iodine-based, acid based, or alkaline based. Some sanitisers are combined with a detergent and perform both a sanitising and a detergent function.

Some sanitisers such as chlorine-based sanitisers (e.g. sodium hypochlorite) may be low cost and have wide anti-microbial properties but are easily inactivated in the presence of organic matter and can be highly corrosive (depending on concentration) on milk harvesting equipment. Furthermore, products such as sodium hypochlorite are not registered by the Australian Pesticides and Veterinary Medicine Authority (APVMA) for use in the cleaning of milk harvesting equipment.

Time

The wash phase must be long enough to remove the soil. Contact time is a function of both volume and (re) circulation time. If one is reduced, then the other must be increased if contact time is to be maintained. The greater the soil load the greater the contact time required for an effective clean. An increased contact time can be achieved by extending the recirculation time or by increasing the total volume of water in a wash tank. When extending the contact time, consideration must be given to the impact it has on the temperature of the wash solution.

Different practices in different countries result in different recommendations for wash contact times.

The recommendations vary between 2–10 minutes, depending on the soil load. In Australia, most detergent label directions specify between 3–5 minutes of recirculation time (which is a proxy for contact time).

Recirculation must be stopped when the wash solution temperature drops to 60°C (or what is specified on the detergent's label directions). If allowed to continue soil will redeposit on to the milking machine.

In principle, 5 minutes is considered the maximum recirculation time unless a re-heating takes place.

Drainage

It is essential that drainage be effective between each cleaning cycle so that the solutions do not interfere with each other and no accumulated solutions remain in the system.

Poor machine drainage can lead to/result in three types of problems:

1. **Microbial contamination:** If water remains in the machine, it can be a source for microbial contamination, even if the water is from the hot water system. Hot water is generally considered almost microbe free, but after several hours in the milking machine any organisms present in this moist/wet environment will be able to multiply during the non-use period. At the next milking, this contamination is 'picked-up' by the milk and transferred to the bulk milk vat.
2. **Residue contamination:** Cleaning solutions, particularly sanitisers, which remain in the milking machine, can end up in the bulk milk tank. These residues can adversely affect product manufacture and product quality.
3. **Reduced cleaning performance:** in circumstances where poor drainage results in retention of large quantities of the cleaning solution, it will contaminate and potentially dilute the chemical concentration of the subsequent cycle, thereby reducing its effectiveness.

Equipment maintenance

All rubber components must be changed on a regular basis. Research from the mid-1970s demonstrated that the cleanability of rubber surfaces decreases over time due to increased surface roughness. A rough surface provides an excellent site for bacterial contamination and growth. This research indicates that bacterial contamination in liners after 4,000 cow milkings is six times higher than in liners after 2,000 cow milkings.

Any worn machine components whose surfaces have contact with milk should be replaced. Difficult-to-clean components, such as the milk filter body or milk receiver, should be inspected daily to ensure their surfaces are clean.

The milking machine should be maintained according to the manufacturer's specifications to ensure that its performance is capable of meeting the requirements for cleaning. Of particular concern are the following performance characteristics:

1. **Working vacuum level:** appropriate for the configuration of the milking system.
2. **Effective reserve:** sufficient to cater for the cyclic air admissions by the air injector.
3. **Milk pump capacity:** can accommodate the higher flow rates which occur during washing, especially immediately after a wash slug.
4. **Air leaks:** air leaks are uncontrolled air admissions and can hamper the turbulence effectiveness of a wash cycle. They can also compromise water flow rates.
5. **Pipe slopes:** correct slopes enable drainage.

Other parts of the system

The wash lines and jetters should be routinely inspected for cleanliness and restrictions (blockages).

Drain valves should be routinely inspected to ensure their correct operation.

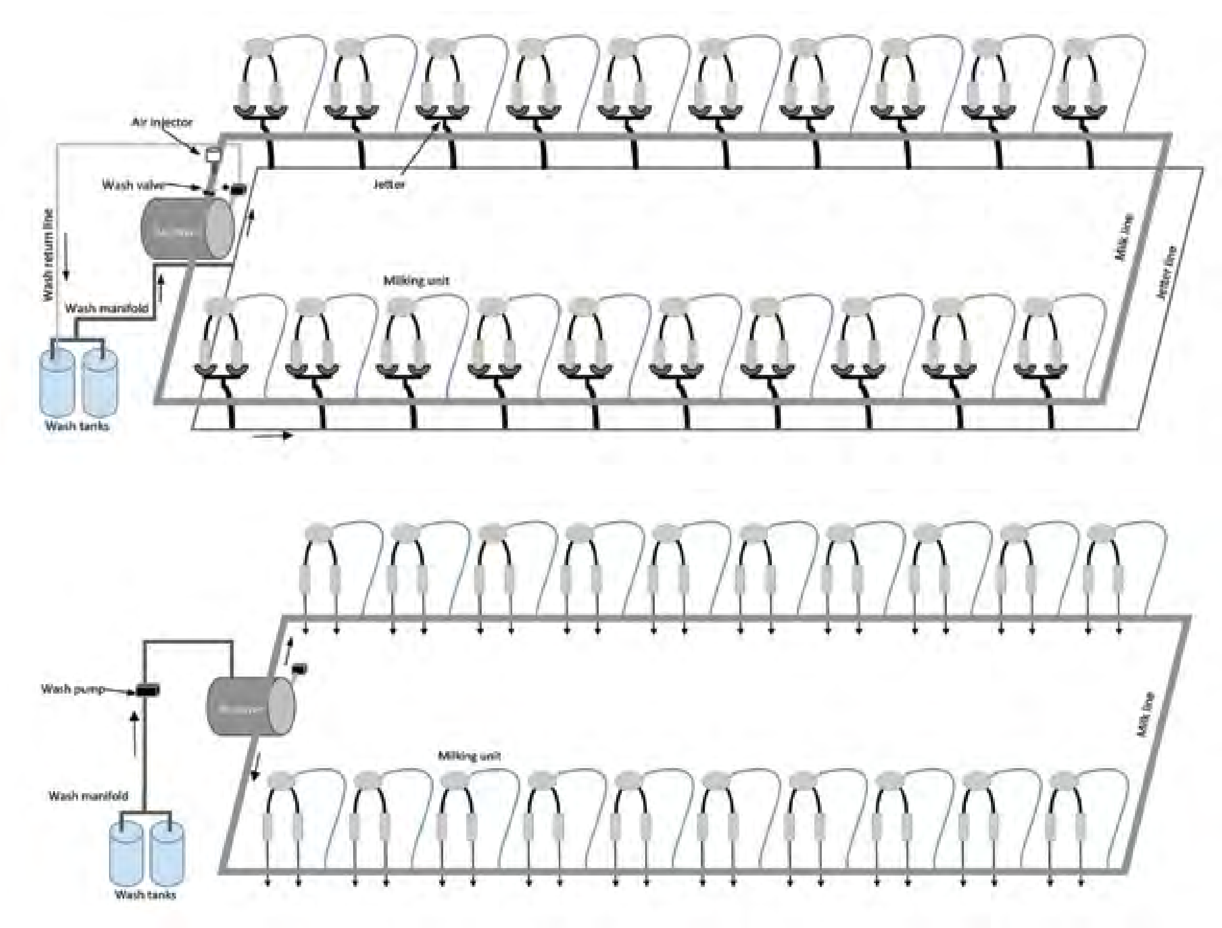
CLEANING SYSTEMS

Cleaning methods

Three methods of cleaning milking machines have been used in Australia.

1. **Bucket cleaning:** This method is associated with older and smaller dairies and is rarely practiced. It is a manual method of cleaning that involves the immersion of the clusters in buckets of hot cleaning solutions. Further information on bucket cleaning can be found in the Alfa Laval Agri Dairy Hygiene and Detergent Handbook (O'Callaghan 1997).
2. **Reverse flow cleaning:** Is used in some large machines, in Australia and New Zealand. Its only benefit is time saving. Reverse flow is less cost-effective and does not clean as well as the CIP (jetter) system. Liners generally do not wash well and it is very difficult to create sufficient turbulence in the milk line. It uses more water and chemicals (to achieve adequate contact time), and uses more energy. For these reasons reverse flow cleaning is not recommended as an effective and efficient way to clean milking machines.
3. **Cleaning in Place (CIP):** CIP or jetter cleaning is the most popular method of cleaning in Australia. It is time, energy, and cost effective. In Australia, there are two methods to connect clusters to jetters for cleaning; most commonly where the cluster connects in an 'inverted' position or less commonly where the cluster connects in a normal milking orientation.

Figure 28 Diagrams of two cleaning systems. Top: Jetter CIP, bottom: Reverse flow



CLEANING PROGRAM

The cleaning program refers to the activities and procedures deployed in cleaning, comprising the wash program and the wash routine.

Wash program

Elements of the wash program

Whilst there are many different types of milking systems and subsequent cleaning systems, the approach to cleaning has three elements that are common to all (**Figure 28**).

1. **Pre-rinse or, more accurately, pre-wash rinse** (some refer to this as the post-milking rinse, post-rinse, 1st rinse, or just rinse). Its purpose is to remove as much of the milk residue as possible. This improves the effectiveness and efficiency of the subsequent cycle: the wash.
2. **Wash.** Its purpose is to clean the equipment of all residues (soil, milk, etc.).
3. **Final rinse** (or post-wash sanitising rinse). Its purpose comprises rinsing and sanitation of the equipment.

For efficient and effective cleaning all three elements must be undertaken (**Figure 29**). In some wash programs the second and third elements may be combined.

Pre-rinse

The pre-rinse is the uses of clean water flow that circulates through the equipment immediately after milking, for milking machines or immediately after emptying the bulk milk vat. This cycle is not recirculated; the pre-rinse water passes through the equipment once and then goes to drain. The objective is to remove as much of the residues as possible. At least 90% of the residue will be removed with an effective pre-rinse.

Improving the pre-rinse

Using a warm pre-rinse (ideally 38ºC, although 35–38ºC is acceptable) is beneficial as it removes more residues than a cold/ambient temperature pre-rinse and helps to warm the equipment which reduces the temperature drop during the subsequent cycles.

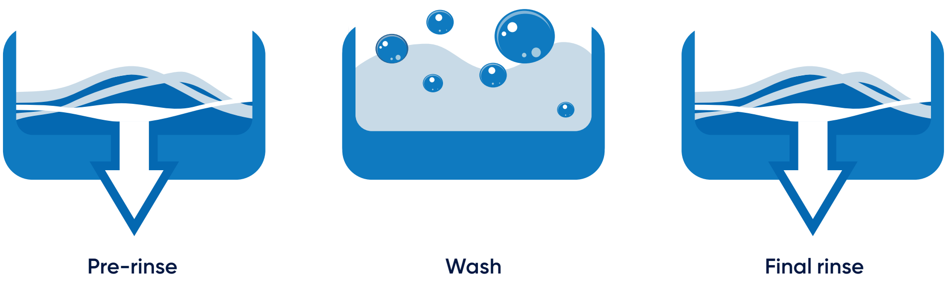
Pre-rinse additives (or rinse aids) are wetting agents that are sometimes used. When added to the pre-rinse water they improve the effectiveness of the rinse. A warm pre-rinse with an additive is claimed to increase the amount of milk residue removed from the milking machine from 90% (without the additive) to 95% (with the additive).

Increasing pre-rinse volumes can also be used to increase the amount of residue removed. Pre-rinse volumes are usually the same as the volume used for the subsequent cycles.

On larger milking machine installations 40–80 litres of milk can remain in the system. Equipment that can safely purge and move this 'left-behind' milk into the bulk milk tank is very cost effective. When the milk at the end of milking remaining in the milk delivery system (receiver, pipes, filter body, plate cooler) cannot be retrieved additional pre-rinse volumes are required.

The volume of pre-rinse water used should be sufficient to result in water at the drain point to be clear. However poor lighting or eyesight and subjective interpretations can lead to inappropriate volumes being used. A trial conducted by the National Milk Harvesting Centre, Ellinbank found that pre-rinse water judged to be clear by milking staff was found to contain 20% milk residue.

Figure 29 The three elements essential for effective cleaning



Wash

The wash is the cleaning phase. It uses a detergent, typically in hot (60–85ºC) water. It follows the pre-rinse cycle and its task is to remove all remaining residues and leave surfaces clean. The wash cycle is recirculated, if enabled by the cleaning method, to facilitate sufficient contact time, after which it is discarded.

The type of detergent used will be dictated by the prevailing conditions: soil load, water quality, water availability (quantity and temperature), any regulatory requirements, and the cleaning method used.

These complex conditions mean that a detergent from each of the two main groups of detergents (acid and alkaline) will be required (see *Chemical energy* on page 29). Further choices are then made within each group. The requirement for two different types of detergents means that their use is alternated or interchanged. This is usually referred to as the 'alternating wash cycle'. The frequency of alternation is governed predominately by water hardness: the harder the water the more frequent must be the use of an acid detergent.

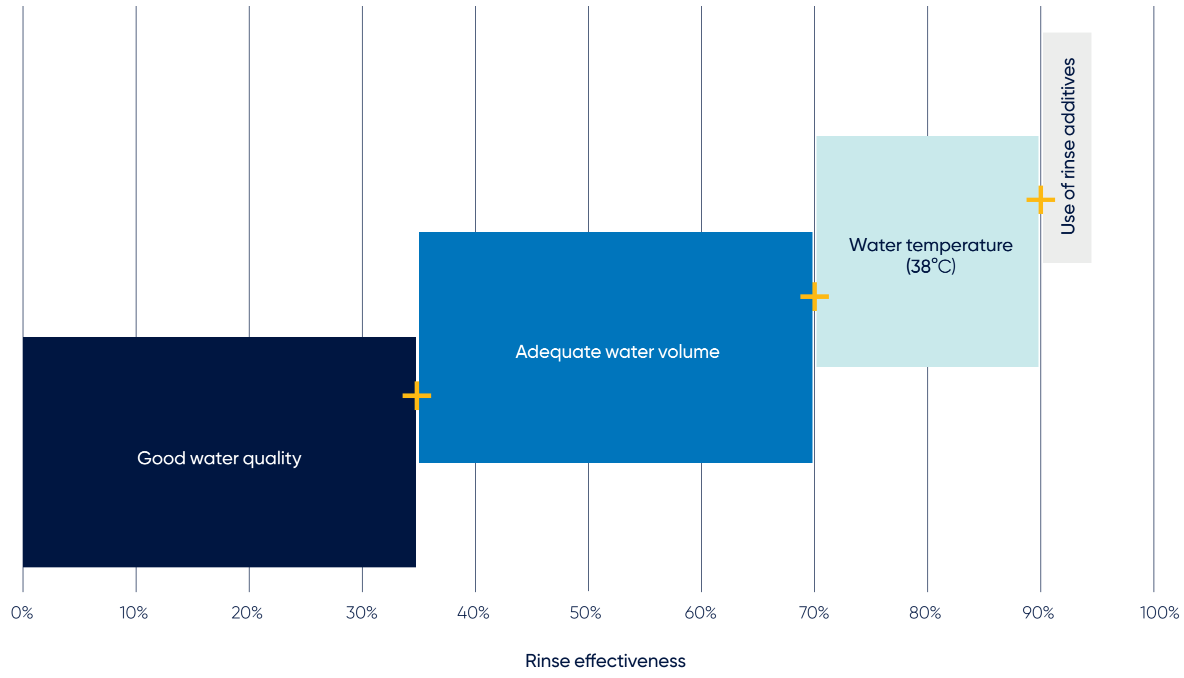
Always refer to the details and directions provided on the product label.

Final rinse

Like the pre-rinse, the task of the final rinse is to remove any residues remaining from the previous activity – in this case the wash and any chemical residues. Unlike the pre-rinse, after the final rinse the cleaned surfaces should be also microbe-free (or as microbe free as possible). Therefore, the final rinse incorporates a sanitising function, which can be achieved by using hot water (thermal sanitation) or a chemical sanitiser. Where an alkali detergent cycle is followed by an acid sanitiser cycle (e.g. wash program 3 in **Table 19** on page 39) an intermediate rinse cycle is required.

Refer to the sanitiser's label for specific directions.

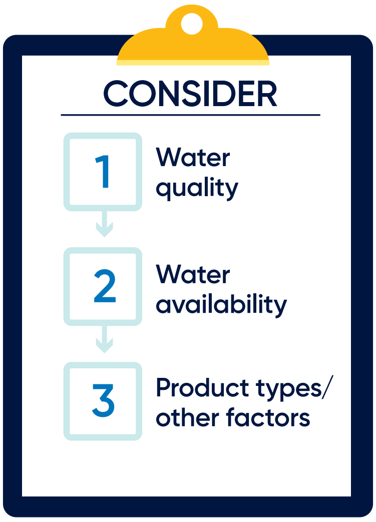
Figure 30 Pre-rinse effectiveness is governed by several important factors



Types of wash program

Every wash program must comprise the three essential elements: the pre-rinse, the wash, and the final rinse. Water quality in terms of water hardness and iron content, and hot and cold water availability will influence the manner in which the program is executed. This results in the recommendation of two different types of wash programs for Australian conditions. One is the alternating wash program, the other the acid-dominant wash program (details provided on page 37). Each wash program then will be further tailored to the specific conditions found on farm. However, the process of selecting the most appropriate wash program must follow a series of considerations **(Figure 31**).

Figure 31 The considerations when selecting a wash program



Consideration 1:
Water quality – hardness and iron content

Water hardness affects the effectiveness of alkaline detergents. Some detergents cannot be used in hard water. The presence of iron also has a detrimental effect: the higher the level of iron, the higher the alkali dose rate must be. Hence water hardness must be the first consideration.

Water that is extremely hard (>700ppm, $CaCO_3$, see **Table 13** on page 24), or has high levels of iron (>3.0ppm) can be considered to be of poor quality for cleaning purposes, and as such should be allocated to an acid-dominant wash program.

Water with lower levels of hardness and iron can be allocated to an alternating wash program.

Consideration 2:
Water availability – cold and hot

How much water is available will affect the number of cycles that can be performed at each wash, and the availability of hot water will affect the temperatures of each cycle. This applies to both alternating and acid-dominant wash programs.

Generally, hot water availability is the limiting consideration (due to the capacity of the hot water service(s) relative to the number of milking units), though during times of drought access to 'cold' water of suitable quality may place additional constraints on the selected wash program.

Consideration 3:
Product types and other factors

Selection of the products to use is now made easier since the wash program has been chosen and the possible types of cycles (number and temperature) identified. Other factors such as economics and product availability can be considered before the condition-specific wash program is finally selected.

Alternating wash program

This wash program involves the alternating use of acid and alkali detergents. Typically, the alkali detergent is used for the morning (am) wash and the acid detergent for the evening (pm) wash. This is repeated each day of the week.

In an alternating wash program, it doesn't matter whether the alkali is used in the morning wash and acid is used in the night wash, or vice versa. However, what is important is that there is sufficient hot water – at the required temperature – to satisfy each and every cleaning cycle.

Table 15 is an example of an alternating wash program. In this example, the three essential elements – pre-rinse, wash, and final rinse – are carried out in three separate cycles. The use of the three separate cycles also implies that there is sufficient water available.

For situations where hot water may be limited chemical sanitisers may substitute the sanitising function of the final rinse. Some chemicals combine the detergent and the sanitising functions into one product, the most common of which is an acid detergent and sanitiser. This combines the function of an acid detergent and a sanitiser. In recent years, alkaline sanitisers, and alkaline detergent and sanitisers have emerged on the market. As of June 2016, one product is registered on the APVMA website. However, it is no longer used in cleaning dairy equipment as it contains quaternary ammonium compounds (QAC).

Table 15 Example of an alternating wash program

Cleaning	Pre-rinse		Wash		Final rinse	
Session	Description	**Frequency**	**Description**	**Frequency**	**Description**	**Frequency**
AM	Water	7 days	Alkali detergent	7 days	Water	7 days
PM	Water	7 days	Acid detergent	7 days	Water	7 days

Acid-dominant wash program

The acid-dominant wash program is an acid based program, specifically suited for hard water conditions. It involves the use of an acid detergent for every wash. Twice per week a heavy duty alkali detergent is used in place of the acid detergent.

This program should be used if water is extremely hard (>700ppm $CaCO_3$), or contains large amounts of iron (>3.0ppm). An example of an acid-dominant wash program is given in **Table 16**. Twelve of the 14 washes per week are acid-based, and two of the AM washes use an alkali detergent. Like the previous example there is sufficient water available to carry out the three essential elements in separate cycles.

Table 16 Example of an acid-dominant wash program

Cleaning	Pre-rinse		Wash		Final rinse	
Session	Description	**Frequency**	**Description**	**Frequency**	**Description**	**Frequency**
AM	Water	5 days	Acid sanitiser	5 days	Water	5 days
AM	Water	2 days	Alkali sanitiser	2 days	Water	2 days
PM	Water	7 days	Acid sanitiser	7 days	Water	7 days

In this example, acid is used for five mornings and alkali is used for two mornings every week. For instance:

Sun	Mon	Tues	Wed	Thurs	Fri	Sat
alkali	acid	acid	alkali	acid	acid	acid

If water availability was very limited the wash program may be altered. Selecting an alkali sanitiser, and an acid sanitiser, both of which do not require rinsing could result in the wash program shown in **Table 17**.

Table 17 Example of an acid-dominant wash program for conditions where water availability is severely limited

Cleaning	Pre-rinse		Wash		Final rinse	
Session	Description	**Frequency**	**Description**	**Frequency**	**Description**	**Frequency**
AM	Water	5 days	Acid sanitiser	5 days		
AM	Water	2 days	Alkali sanitiser	2 days		
PM	Water	7 days	Acid sanitiser	7 days		

There may be situations where an acid dominant wash program is selected despite not satisfying the criteria above. For example, there could be a situation where water hardness is 400ppm but a suitable alkali detergent – to use in an alternating wash program – is unavailable.

Tailoring the wash program

There is a multitude of different types of detergents and sanitisers available to clean and sanitise milking equipment and bulk milk tanks. After consideration has been given to water quality and water availability, and a wash program is selected, the options relating to product type, economics, and cycle characteristics can be considered.

Nine of the most popular tailored wash programs are listed in **Table 19**. Local circumstances, such as product pricing and water heating costs, will influence the preferred wash program.

To narrow the choice first use the two criteria **water quality** and **hot water availability** to select an appropriate wash program (number) given in **Table 18**. The number selected refers to a wash program detailed in **Figure 24**.

Table 18 Program selection guide based on quality of water and hot water availability

Water quality	Hot water availability*		
	Sufficient*	**Limited**	**None**
Good	1	3, 4, 5, 6	9
Poor	2	7	8

**Sufficient means, enough hot water to satisfy the day's volume requirement for the pre-rinse, wash, and final rinse cycles. To estimate water quantity requirements, see the section titled 'Water quantity' on page 22.*

Table 19 Wash programs for Australian conditions

Wash	Cleaning session	Pre-rinse			Wash			Final rinse		
Program number		Temp	Description	Frequency	Temp	Description	Frequency	Temp	Description	Frequency
1	AM	Warm	Water	7 days	Hot	Alkali detergent	7 days	Hot	Water	7 days
	PM	Warm	Water	7 days	Hot	Acid detergent	7 days	Hot	Water	7 days
2	AM	Warm	Water	5 days	Hot	Acid detergent	5 days	Hot	Water	2 days
	AM	Warm	Water	2 days	Hot	Alkali detergent	2 days	Hot	Water	5 days
	PM	Warm	Water	7 days	Hot	Acid detergent	7 days	Hot	Water	7 days
3*	AM	Warm	Water	7 days	Hot	Alkali detergent	7 days	Cold	Acid sanitiser	7 days
	PM	Warm	Water	7 days	Hot	Acid detergent	7 days	Cold	Acid sanitiser	7 days
4	AM	Warm	Water	7 days	Hot	Alkali detergent	7 days	Hot	Water	7 days
	PM	Warm	Water	7 days	Warm	Acid detergent & sanitiser	7 days			
5	AM	Warm	Water	7 days	Hot	Alkali detergent	7 days	Hot	Water	7 days
	PM	Warm	Water	7 days	Cold	Acid detergent & sanitiser	7 days			
6	AM	Warm	Water	7 days	Warm	Alkali detergent & sanitiser	7 days			
	PM	Warm	Water	7 days	Cold	Acid detergent & sanitiser	7 days			
7	AM	Warm	Water	5 days	Hot	Acid detergent & sanitiser	5 days			
	AM	Warm	Water	2 days	Hot	Alkali detergent	2 days	Hot	Water	2 days
	PM	Warm	Water	7 days	Cold	Acid detergent & sanitiser	7 days			
8	AM	Cold	Water	7 days	Cold	Acid detergent & sanitiser	5 days			
	AM	Cold	Water	7 days	Cold	Alkali detergent	2 days			
	PM	Cold	Water	7 days	Cold	Acid detergent & sanitiser	7 days			
9	AM	Cold	Water	7 days	Cold	Alkali detergent & sanitiser	7 days			
	PM	Cold	Water	7 days	Cold	Acid detergent & sanitiser	7 days			

**When an alkali-based cycle is immediately followed by an acid-based cycle (or vice versa) an intermediate rinse cycle is required to prevent the risk of compromising the cleaning and/or sanitising performance, and more importantly, reduce the risk of the production of potentially harmful chemical by-products.*

Bomb cleaning

Bomb cleaning is used as a 'last resort' to correct an ineffective wash program or when a build-up has occurred. Bomb cleaning (or shock treatment, as it is referred to sometimes) should never be used as part of a normal wash program routine. As the detergent solutions used to bomb clean are extremely corrosive, always ensure the correct safety/protective clothing is worn, i.e., overalls, face mask and gloves.

Example of a bomb clean procedure

1. Rinse machine after milking with warm 35–38ºC.
2. Wash machine with hot 85ºC acid solution mixed at the label rate. Recirculate for 5 minutes.
3. Rinse with hot 85ºC water.
4. **Slowly** make a wash solution using a chlorinated alkali detergent specific for bomb cleaning – at the label recommended dose rate – with water not hotter than 85ºC (follow label directions for specific temperature requirements). Note: If the water is too hot, or if detergent is added too quickly, the water will boil instantly – an extremely dangerous situation. Recirculate for 5 minutes.
5. Rinse machine with hot, 85ºC water.

Read label carefully and follow directions. Always check with the detergent manufacturer/supplier regarding suitability and dose rates for bomb cleaning.

Using off-label dose rates are illegal in most dairying states.

Ensure there is sufficient hot water to complete the wash.

Re-use cleaning systems

In conventional cleaning systems the rinse and wash solutions are only used once and then discarded.

In re-use systems the wash and chemical sanitiser cycles are captured for re-use. The pre-rinse is not re-used. The method of cleaning is CIP.

The number of re-use cleaning systems in operation is small but growing. Most re-use systems on farms tend to be 'one-off' systems that are manually operated and farmer-managed. The wash solutions particularly the alkali detergents are kept and used at high temperatures (~85ºC). Anecdotal information shows that good cleaning is achieved when the systems are closely monitored and well managed. Those requiring high temperatures for successful operation tend to be less energy efficient as thermal energy losses can be high.

Green Cleaning™ systems

Since 2011, a few commercial systems have become available through milking equipment and detergent distributors. They are generally referred to as Green Cleaning™ systems, the name taken from the dairy industry project (Hakim and Greenall 2010) which researched and then developed a prototype re-use cleaning system **(Figure 32)**.

Green Cleaning™ systems are milking machine wash systems that operate at low temperatures, re-use the cleaning solutions and are energy efficient.

They comprise an automated cleaning unit that is capable of capturing, storing, and re-using the wash solutions.

They use chemicals that are specifically designed for re-use and to work at lower temperatures (less than 50ºC).

Heating of the wash solutions utilises energy from renewable sources such as solar and heat recovery. The storage tanks are well insulated to minimise any heat losses.

Table 20 highlights some of the differences between conventional and Green Cleaning™ systems.

Figure 32 Components of a Green Cleaning™ system

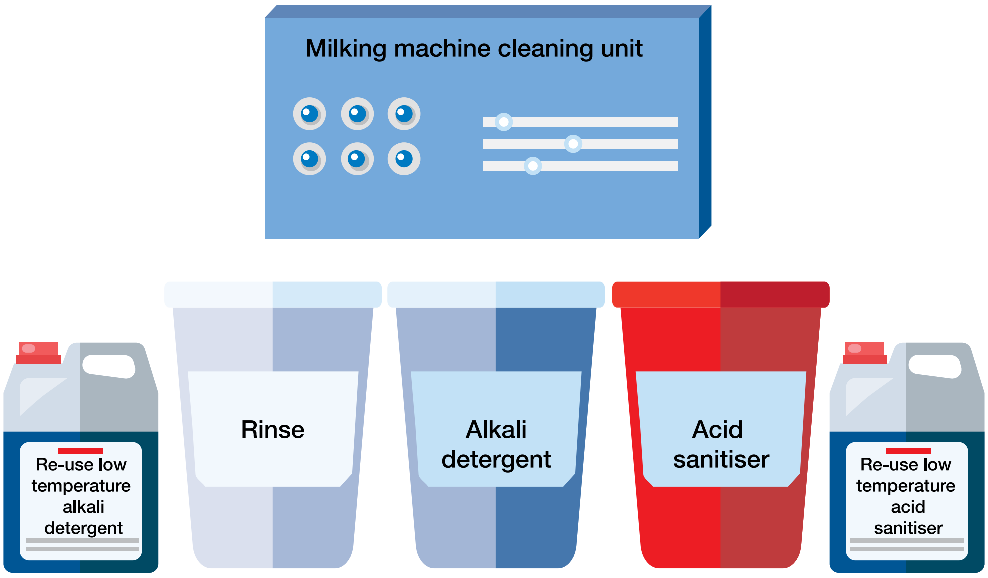


Table 20 Comparison between conventional cleaning and Green Cleaning™ systems

	Conventional cleaning system	Green Cleaning™ system
Temperature of cleaning solutions	High	Low
Uses hot water to sanitise	Yes	No
Uses chemicals to sanitise	Sometimes	Yes
Re-use wash solutions	No	Yes
Water use	High	Low
Chemical wash cycles am/pm	Alternating alkali/acid	Alkali and acid used every wash
Heat losses	High	Low
Electricity use	High	Low
Detergents used	Conventional	Designed for low temperature, re-use

Bulk milk tank wash programs

Almost all new bulk milk tanks sold since the mid-1990s have automatic cleaning systems. The degree of flexibility to adjust the wash program varies enormously between brands and between models within a brand. Often the wash programs are coded (similar to that on automatic wash controllers for milking machines) and may require a service technician to make adjustments.

The wash program for a bulk milk tank should follow the same principles as for cleaning milking machines. The program must include a pre-rinse, a wash, and a final rinse. The same requirements for water quality apply, although greater attention is required to ensure the water is free of suspended solids as these can block filters/strainers and spray heads.

There are two factors specific to cleaning bulk milk tanks that will influence the wash program. These are:

1. **Rinse requirements:** After the milk has been emptied the milk contact surface inside the vat is cold. The milk residues are also cold – they will require greater effort to remove (compared to when they are at body temperature). Milk foam may be present and will also need removing. To minimise the risk of damage to the evaporator plates (on the other side of the milk contact surface) sudden changes in temperature are discouraged by vat manufacturers. To accommodate these conditions, the rinsing procedure is often different to that used for milking machines. There often are two rinses; the first is cold to remove the milk foam as well as the milk residue. The quantity of water used may be greater for this cycle. A second rinse is usually warm, it further removes milk residues and helps to raise the temperature of the milk contact surfaces in preparation for the subsequent hot wash. Some wash programs may combine the two rinse actions into one; i.e. the first part of the rinse uses water at ambient temperature which progressively becomes warmer.
2. **Temperature limitations:** To minimise risks of damage to evaporator plates, manufacturers place a maximum water temperature of 70ºC for cleaning inside the vat. This can affect the approach to sanitisation and the types of detergents used. Most vats source their hot water from a dedicated domestic main pressure hot water service (HWS). These typically have a maximum heating temperature of 70ºC. Operating at lower temperatures may require higher dose rates of chemicals to be used.

Table 21 Example of a wash program for a bulk milk tank

Cycle	Description	Comment
1st Cycle: Pre-rinse	Cold rinse, single pass	The temperature of the rinse water may be gradually increased to ~35–40ºC. Cycle volume ~2% of tank capacity. This is sometimes increased when excessive milk foam is present.
2nd Cycle: Wash	Hot wash. Alternating alkali/acid (pick-up/pick-up), 60–65ºC (starting temp), recirculate for 5–10 minutes then discard	Some systems may only perform a hot alkali wash. The acid function is incorporated into the sanitising cycle. The number of chemical dosing pumps may indicate the wash programs possible. For example, three dosing pumps may indicate alternating alkali/acid wash and a chemical sanitising rinse. Cycle volume ~1–2% of vat capacity.
3rd Cycle: Intermediate rinse	Cold rinse, single pass	Cycle volume ~1% of vat capacity.
4th Cycle: Sanitising rinse	Sanitising/acid sanitising rinse. Recirculate 4–6 minutes then discard	Temperature may be adjustable on some systems. Cycle volume ~1–2% of vat capacity.
5th Cycle: Final rinse	Cold rinse, single pass	Cycle volume ~1% of vat capacity.

WASH ROUTINE

The wash routine is similar, regardless of whether the wash program is fully automatic or a completely manual affair, the following tasks need to be undertaken.

General routine for a CIP cleaning system

Always wash the milking machine with a filter sock in place. Without it, residues, contaminants and other debris will be deposited in the plate cooler, causing cooling, cleaning, and hygiene problems.

After milking

Ensure there is sufficient hot water to complete the wash.

1 Clean the external surfaces of the clusters and attach them to the jetters – ensure a good seal is established between the liner mouthpiece and the jetter. Lock on the auto shut-off valves on the clusters (if appropriate).
2 Hold milk pump override button on to clear milk from the receiver.
3 Purge milk from the milk delivery system (if milk purging equipment is fitted).
4 Connect CIP hose (for rotaries).
5 Switch on air injector/flushing pulsator.
6 Set the wash butterfly-valve (in the milk line on plants with looped milk lines) to the wash position.
7 Open the tap to allow cleaning solution into the wash bend (at the end of the milk like on plants with dead-end milk lines).
8 Remove milk delivery line from bulk milk tank.
9 Connect milk delivery line to wash return line (if system is automated).
10 Clean filter body.
11 Remove filter sock, rinse, and then refit (do not wash without the filter sock).

Pre-rinse

1 Rinse the plant with sufficient warm (35–38ºC) rinse water (do not recirculate).
2 Hold milk pump override button on to clear rinse water from the receiver.
3 Set milk delivery line for recirculation (if recirculation is manually controlled).

Wash

1 Allow sufficient time for the plant to drain before initiating the wash cycle.
2 Wash the plant with sufficient water, containing the correct detergent dose, at the temperature stated on the label. During recirculation ensure wash tank does not empty completely. If it does, cycle volume is insufficient – correction required.
3 If using and alternating alkali/acid detergent program, ensure the scheduled detergent is being used.
4 Inspect clusters to ensure the seal between the liner mouthpieces and the jetters have been maintained.
5 Check to ensure slugs of wash solution are being produced and are creating turbulence in the receiver. Approximately 12–15 effective slugs are required per wash cycle.
6 Cease recirculation after approximately 5 minutes or if the wash solution temperature drops below 60ºC (refer to label directions for specific details).
7 Hold milk pump override button on to clear wash water from the receiver.
8 Switch off air injector/flushing pulsator.

Final rinse

1 Allow sufficient time for the plant to drain before initiating the final rinse cycle.
2 Rinse the plant with sufficient hot (85ºC) rinse water (if using heat to sanitize). Do not recirculate. If using a chemical sanitiser check label directions for temperatures and recirculation information.
3 Hold milk pump override button on to clear sanitiser from the receiver (if using a chemical).
4 Set the wash butterfly-valve (in the milk line on plants with looped milk lines) to the milking position.
5 Close the tap that allows cleaning solution into the wash bend (at the end of the milk like on plants with dead-end milk lines).
6 Open any manually operated drain valves.
7 Remove filter sock and discard.
8 Disconnect CIP hose (for rotaries).
9 Disconnect the milk delivery line from the wash return line (if system is automated).

WORKPLACE HEALTH AND SAFETY (WHS)

Legal requirements, duties of care, responsibilities, risk assessments

There are a number of legal requirements and duties of care related to dairy hygiene.

Bulk milk vats are almost always found to be 'Confined Spaces', following a risk assessment, and are therefore subject to a number of legal requirements. These include Confined Spaces warning signs, entry permits and ensuring everyone who enters the milk vat has had the necessary training and is supported by a trained 'Standby Person'. If the milk vat has a top entry point, then Working at Heights legislation applies.

The use of corrosive chemicals, including acids and alkalis, poses a risk to operators which needs to be minimised by the use of safe handling procedures and personal protective equipment (PPE).

For more information on the safety requirements for Confined Spaces, Working at Heights and Chemical Handling click on the following link to the Farm Safety Starter Kit **http://www.thepeopleindairy.org.au/farm-safety/safetystarterkitdocs** and go to page 28 for Confined Spaces, page 29 for *Working at Heights* and page 38 for *Handling Chemicals Quick Safety Scans*.

Food safety plans and dairy factory quality assurance requirements

Each dairying state requires licenced dairy farms to have a dairy food safety plan, which is often a subset of the milk factory's QA requirements. The dairy food safety plan will contain a section relating to cleaning of milking machines and bulk milk vats. This is where the cleaning program and procedures are documented. The level of detail and documentation required will vary between companies and between jurisdictions.

Any proposed changes to a wash program or procedure must be first checked to ensure it will comply with the dairy food safety requirements. The changes made must be documented and the dairy food safety plan updated.

03

CONDUCTING A DAIRY HYGIENE INVESTIGATION

THE DAIRY HYGIENE INVESTIGATION

Understanding the approach

When reviewing a wash program or investigating a dairy hygiene issue it is important to use an approach that is logical, efficient and consistent. It generally involves a step-wise process of which an example is given in **Figure 33**.

Usually a problem becomes apparent when there is an infringement of one or more quality parameters after which an investigation is initiated.

In Australia, the milk quality parameters used to indicate efficacy of cleaning are Total Plate Count (TPC)/Bactoscan, Thermodurics, Coliform count (not widely used), and Spore count (not widely used).

A description of these parameters is given in **Table 2** on page 4.

Table 22 lists some of the information that can be useful when investigating a problem. Each case can have different characteristics and thus the information to focus on may be different. In most cases, collecting the information described in **Table 22**, answering the questions and undertaking critical analyses will provide a sound base on which the remedy can be implemented.

Figure 33 Step-wise process to investigating a dairy hygiene issue

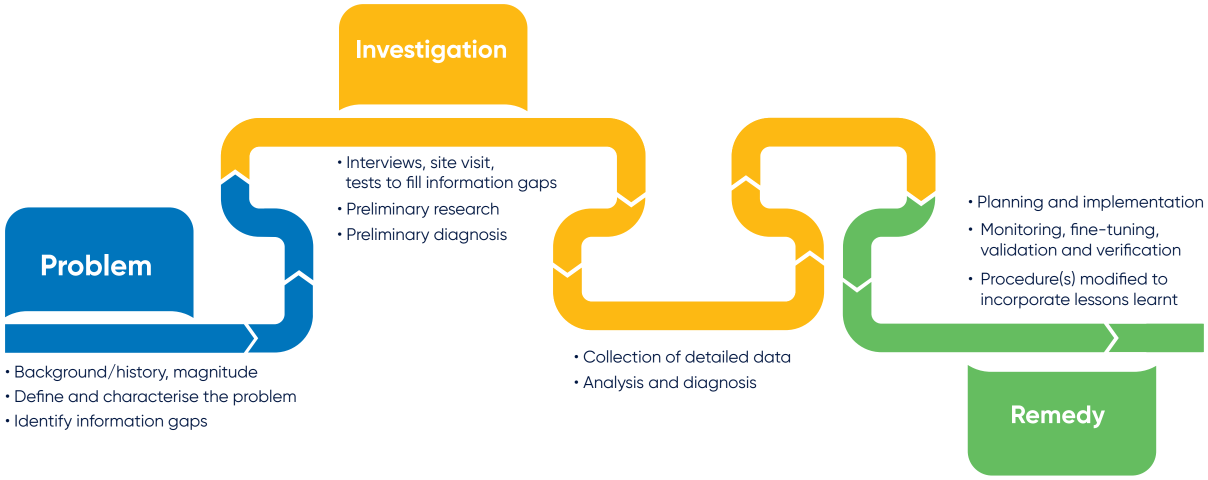


Table 22 Types of information to collect and analyse at each stage of a dairy hygiene investigation

	Types of information
Defining and characterising the problem	**Collection** • Factory quality statements (current and historical -2–3 months) - Bactoscan/Thermoduric results - Milk collection temperatures - BMCC results • Interviews with staff involved with the cleaning process - Practice changes (routines, chemicals, water, staff) - Atypical events (equipment failures, breakdowns) - Errors – human or otherwise • Other documentary information - History of milk quality **Sizing up the problem** • Does it look like a 'one-off' that will be rectified? • Is it a persistent problem? • Are there multiple problems (e.g. financial, BMCC, management)? • Does the information thus far suggest whether the problem is related to **Plant Hygiene, Milking Hygiene, Cooling** or **Mastitis**.
Identify information gaps	What else is needed to make an initial assessment? • Further tests – strategic milk sampling • Cleaning routine specifics (assessment and analysis) • Plant inspection details/results
Investigation	Filling the information gaps by: • Strategic milk sampling • Cleaning program review • Plant inspection • Milking routine review
Analysis and diagnosis	With the information gaps filled and analyses conducted what are the causes for the problem? What needs to happen to rectify the problem?
Remedy	
Planning and implementation	How will the remedies be implemented? Is there requirement for: • Change in practice • Change of equipment • Staff/operator training
Monitoring and validation	How will the changes be monitored to verify that they have remedied the problem? What will happen if the problem persists? What is the review procedure?
Incorporation	If the changes lead to improved outcomes, how will they be incorporated into standard procedures? How will the changes be documented?

The factory results

Strategic milk sampling

Strategic milk sampling is an investigative technique that is sometimes used when the more 'usual' techniques do not readily identify potential causes milk quality downgrades. It is utilised after careful and thorough plant inspections have been conducted and other possible causes have been considered and ruled out. Some of the reasons why strategic sampling is used as a 'last resort' are:

- Causes of milk quality downgrades are usually identified via other means
- Requires and relies on experience and subjectivity when interpreting results
- Time lag in obtaining sample test results (e.g. four days before thermoduric test results are available)
- Expense in testing samples.

How to sample

Successful collection of milk samples for analysis requires an aseptic technique. A poor technique will give misleading results and resampling will be required. A good technique involves some planning.

Have the following ready in the dairy:

- ✓ sterile sample bottles
- ✓ a marker-pen to label the sample bottles
- ✓ a pad/clipboard to record the particulars of the collected samples
- ✓ disposable gloves
- ✓ a cooled esky (containing ice) or similar portable and temporary cooling system

Label the bottles:

- ✓ unlabelled samples are useless, so ensure sample identity
- ✓ do this before collection as it can be difficult to write on a label with milk sprayed on it
- ✓ use the marker-pen to clearly label details of the sample – the date, the reference number, etc.

Figure 34 A sample label with clear identification (example only)

Record the details:

- ✓ Use a reference sheet to record sample details and notes.
- ✓ Allow space to record the test(s) to be undertaken and results obtained.

Figure 35 Example of a reference sheet that allows considerable detail to be captured

Time sample taken	Notes	Test to be conducted	A sample	B sample
2.35pm	Start of milking. Very watery milk. First operation of milk pump	Bactoscan	95,000	106,000
2.38pm	Milk starting to flow	Bactoscan	82,000	74,000
2.45pm	First row of cows almost finished	Bactoscan	65,000	70,000
3.30pm	Midway through milking	Bactoscan	26,000	29,500
4.20pm	Last run of cows	Bactoscan	29,000	104,500
4.30pm	End of milking. 5,800 litres of milk in vat. 1 hr 55 mins to milk 245 cows. Milk at 7.5 degrees.	Bactoscan & thermoduric	(B) 38,000 (T) 15,000	(B) 37,500 (T) 14,000
6.45am	Prior to am milking 25/5. Milk at 4 degrees.	Bactoscan & thermoduric	(B) 62,000 (T) 23,000	(B) 61,000 (T) 24,000

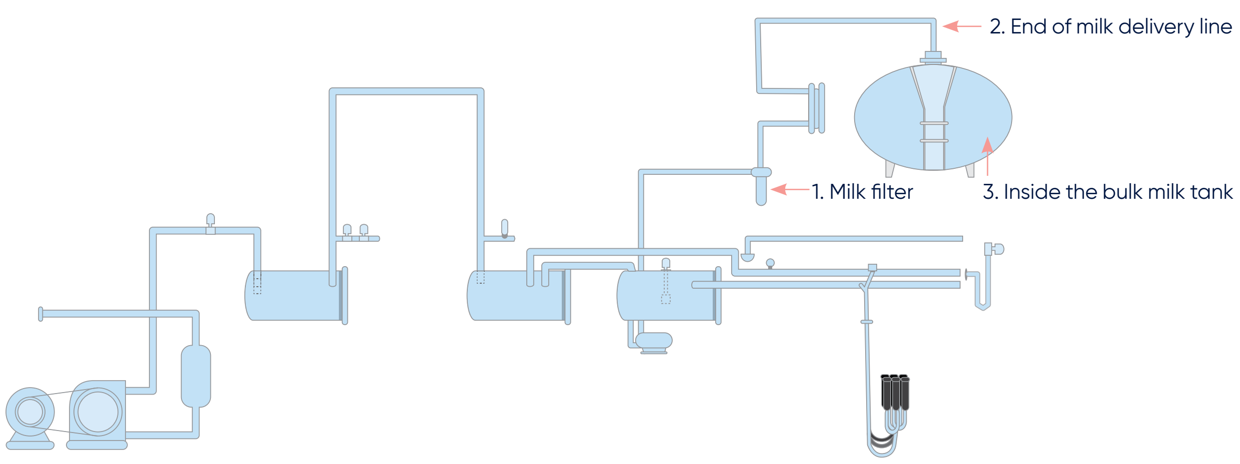
Where to sample

In many modern dairies and rotaries in particular safe and feasible access for strategic sampling is highly limited. A compromise may be the only option. Try to sample from the available access points while the first batch of (say) 20 cows are being milked, then sample again about an hour later. Safety should always take precedence.

Taking milk samples at different locations of the milking system will allow 'hot spots' to be identified, and thereby narrow the investigation. Three locations are:

1. At the milk filter: this includes the milking units, milk line(s), receiver, milk pump(s), and the milk filter
2. At the end of the milk delivery hose: this includes the milk delivery lines, and plate cooler, and
3. Inside the bulk milk tank (vat).

Figure 36 The three locations for strategic milk sampling



When to sample

Milkings can take up to 4 hours, with most sessions taking between 1.5 and 3 hours. Incubation time inside the milking system is not likely to be a significant factor for short milking sessions. However, incubation and growth in the period between milkings (from after the wash to the start of the next milking) can be significant. Hence, when sampling it is important to capture a sample of milk that first passes through the milking system.

It is important to begin with an empty vat that has been washed (as per normal) and is ready to accept milk. This minimises the influence of previously stored milk.

Furthermore, sampling at this early stage should capture any residue solutions from the previous wash that have failed to drain from the plant. In situations where drainage is poor, significant amounts of residual solution may be present and will require the taking of additional samples potentially providing greater insight when interpreting results.

The first sampling should be undertaken after the first group of cows have been milked (i.e. each milking unit has been used once). This will ensure that all milk contact surfaces will be represented.

Another sampling undertaken mid-way through the milking and a final one near the end is sufficient to provide meaningful information.

Ensure the milk has been sufficiently agitated prior to sampling from the bulk milk tank. This will require the agitator(s) to operate for at least 2 minutes beforehand. If a milk sample is taken at the completion of milking undertake it after the milk delivery hose has been disconnected/removed from the vat. Another sample should be taken several hours later – preferably just prior to the next milking. Comparing the results from across this time period may provide an indication of cooling and vat cleaning performances, as well as identify other malfunctions such as ineffective agitation.

Interpreting the results

As with differential diagnosis of bulk milk tank sample results, the method applied to strategic sampling also relies on the relative comparison between numbers to formulate a diagnosis. Making a diagnosis using only one sample location or one time period without consideration of the relative values can be misleading.

Bactoscan/TPC tests should be conducted on the milk samples.

The Bactoscan results in **Table 23** show that the number of bacteria was greatest at the start of the milking (38,000). The count increased significantly in the sample taken at the end of the milk delivery line. During the course of the milking the pattern of numbers remained relatively similar, although the mid-way result for the end of the milk delivery line was slightly elevated.

These results tend to suggest that there is a cleaning failure which allows bacteria to survive and grow in between milkings, and that the area to focus on is between the receiver and the bulk milk tank.

However, these figures should be considered in relation to the factory results (bulk milk tank results). Despite being from different sampling times (days) as well as different sampling techniques the consideration still can be instructive. For example, the factory results will provide historical results as well as additional information. The report in **Figure 37** shows that milk is consistently being picked up at the required 4ºC, Bactoscan results have been rising, and thermoduric counts have been very high. These results suggest a cleaning problem and are consistent with the strategic milk sampling results.

Table 23 Example of Bactoscan results from strategic sampling indicating poor plant hygiene

Sampling date: 10/11/2013	Bactoscan			
	Approx. time	At receiver	End of milk delivery	Bulk milk tank
After 1st group of cows	6:45am	38,000	67,000	64,000
Mid-way through milking	7:35am	28,000	35,000	38,000
Last group of cows	8:15am	30,000	29,000	32,000

Differential diagnosis

The use of differential diagnosis is not well established in Australia. Work is required to determine how to best interpret the results, given most cows are grazed on pasture and the milking routine rarely involves any teat preparation practiced in the northern hemisphere dairying countries.

The method relies on the relative comparison between numbers to formulate a diagnosis.

The most common misapplication of the method is the formulation of a diagnosis based on only one of these numbers without considering the relative values of the others.

There is a growing trend amongst milk factories to reduce the number and types of tests being conducted. For example, several factories only conduct thermoduric tests as an advisory procedure.

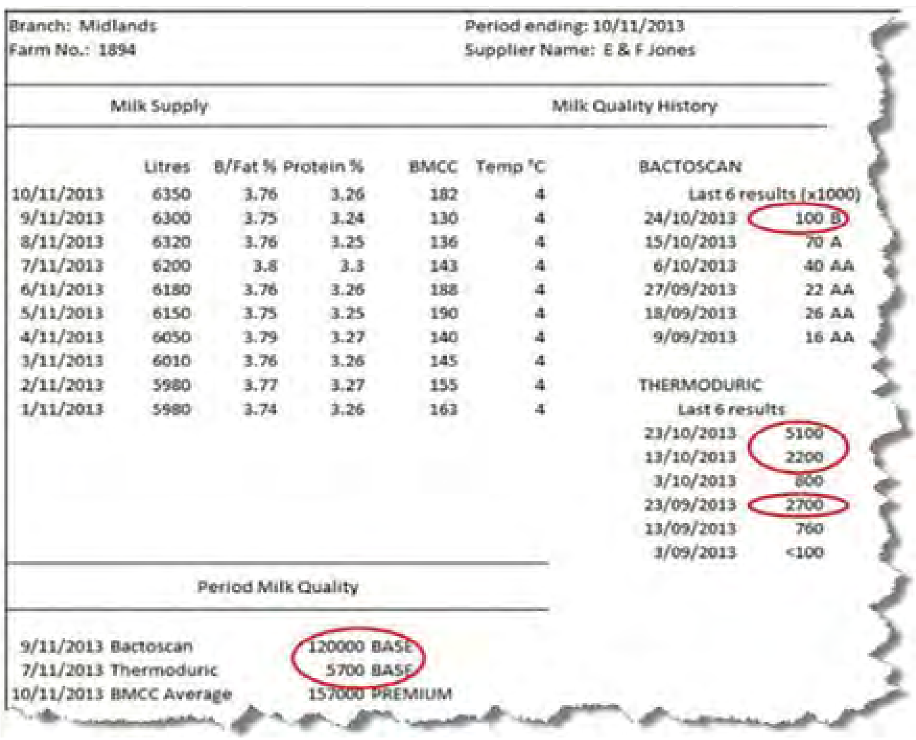
For Australian conditions, where the number of routine results available is limited to Bactoscan/TPC and thermodurics the power of differential diagnosis is reduced. Supporting the differential diagnosis with strategic milk sampling can help the initial diagnosis.

When interpreting the results from the milk quality parameter tests it is beneficial to remember that:

- **Bactoscan** is an electronic count of all bacterial cells (alive or dead).
- **Total Plate Count** is a culture of viable bacteria that have grown and multiplied. It is a broad spectrum culture.

  Sometimes a comparison between TPC and Bactoscan is made where a TPC of 1 cfu/ml is approximately equal to a Bactoscan of 4 (ibc/ml), i.e. 20,000 cfu/ml ≈80,000 cells/ml. However, some studies (Cassoli et al. 2007; Ramsahoi et al. 2011) show that the relationship is more complex and that using the approximate comparison ratio of 1:4 (TPC: Bactoscan) is not appropriate as there can be a wide variation in TPC for a given Bactoscan result, making this 1:4 linear relationship invalid.
- **Thermoduric Count** is a culture of viable bacteria that have survived pasteurisation to grow and multiply. Mastitis causing bacteria and most environmental bacteria (e.g. coliform bacteria) do not survive pasteurisation and therefore do not contribute the thermoduric count.

Figure 37 Example of a factory summary milk quality report


Branch: Midlands
Farm No.: 1894

Period ending: 10/11/2013
Supplier Name: E & F Jones

Milk Supply

	Litres	B/Fat %	Protein %	BMCC	Temp °C
10/11/2013	6350	3.76	3.26	182	4
9/11/2013	6300	3.75	3.24	130	4
8/11/2013	6320	3.76	3.25	136	4
7/11/2013	6200	3.8	3.3	143	4
6/11/2013	6180	3.76	3.26	188	4
5/11/2013	6150	3.75	3.25	190	4
4/11/2013	6050	3.79	3.27	140	4
3/11/2013	6010	3.76	3.26	145	4
2/11/2013	5980	3.77	3.27	155	4
1/11/2013	5980	3.74	3.26	163	4

Milk Quality History

BACTOSCAN

Last 6 results (x1000)	
24/10/2013	100 B
15/10/2013	70 A
6/10/2013	40 AA
27/09/2013	22 AA
18/09/2013	26 AA
9/09/2013	16 AA

THERMODURIC

Last 6 results	
23/10/2013	5100
13/10/2013	2200
3/10/2013	800
23/09/2013	2700
13/09/2013	760
3/09/2013	<100

Period Milk Quality

9/11/2013 Bactoscan	120000 BASE
7/11/2013 Thermoduric	5700 BASE
10/11/2013 BMCC Average	157000 PREMIUM

Cleaning program review

When reviewing a cleaning program, it is critical that all the elements that contribute to the program are investigated. Checking the detergents or how much hot water is used will not provide sufficient information to make a proper assessment.

The essential elements are:

- Water: quantity *and* quality
- Energy: thermal energy, kinetic energy (turbulence), chemical energy, and contact time
- Equipment: drainage and maintenance
- Wash program: the pre-rinse, the wash, and the final rinse
- Wash routine: the steps and procedures
- Skills: skills and competency to manage and carry out the cleaning program.

A site visit is usually required to obtain accurate and reliable information.

Water quality and water quantity review

Determine the **source** of the water used for cleaning the milk harvesting equipment. There may be multiple sources used concurrently (e.g. bore water for the pre-rinse, and rain water for the subsequent cycles) and whether the source changes over time.

Determine the **quality** of water. Use water taken from the HWS as this is the water to which detergents will be added. Also this will incorporate any contribution by the HWS (through corrosion). Using an appropriate water test kit, determine:

- pH
- Total hardness – ppm ($CaCO_3$)
- Total iron – ppm.

Compare the test results with the guide in **Table 13** on page 24.

Determine the delivery capacities of, and temperatures to which water is heated in the hot water services supplying the milking machines and bulk milk tank wash systems.

Table 24 Example of water records taken during a water quantity and quality investigation

Water details

Water source(s)	
For hot water: *Rain water*	For cold water: *Bore water*
Comments: *Uses bore water for the pre-rinse. Rain water for the wash and final rinse. Over summer may need to add some bore water to the rain water tank.*	
Water quality results	
Date of test: *29/11/2016*	Water sample taken from: *Hot water service, cold water tap*
pH: *7 (HWS) 8 (cold water tap)*	*E. coli* count (cfu/ml): *0 (HWS) 50 (cold water tap)*
Iron (ppm): *0 (HWS, cold water tap)*	Total plate count (cfu/ml): *<10 (HWS), 100 (cold water tap)*
Total hardness ($CaCO_3$) (ppm): *30 (HWS) 160 (cold water tap)*	

Table 25 Example of dairy and equipment particulars related to cleaning

Equipment details

Dairy	
Type of dairy	◯ Rotary ◉ Swingover ◯ Double-up ◯ AMS/AMR ◯ Walkthrough
No. units:	*22*
Milk line size (mm):	*100*
Air injector:	☑ Yes ☐ No
Bulk milk tank capacity (Litres):	Tank 1: *9,700* Tank 2:

Cleaning method	Auto CIP	Manual CIP	Manual
Milking machine	☐	☑	☐
Bulk milk tank 1	☑		☐
Bulk milk tank 2	☐		☐

Hot water services capacities	Volume (Litres)	Temp (°C)
Milking machine HWS1:	*1,260*	*92*
Milking machine HWS2:		
Bulk milk tank 1:	*315*	*65*
Bulk milk tank 2:		

To determine the temperature characteristics of each wash cycle, the effectiveness of the turbulence and the cycle times, a complete wash routine must be observed.

Use the **Table 25** as a guide to the information to collect. When recording the chemical dose rates, note the programmed (if auto dispensing) rate or rate given on the dairy's wash instructions and compare this with what is actually dispensed. Exercise appropriate safety when handling chemicals.

Determine the volume of water used for each cycle:

- How does this compare with the guideline? (Refer to Water quantity on page 22). For bulk milk tanks refer to the guide in **Table 11** (page 23) or the manufacturer's specifications.
- If observing a wash, check to see that the water level inside the wash drum does not fall below the suction/intake line.

Some points to remember:

- Always measure/calculate the volume. Assumptions are often incorrect! Appendix 2 explains how to take measurements and perform the calculations.
- Exercise safety when measuring hot water temperatures.
- Be mindful at the time of measurement as to whether hot water has been recently drawn from the unit and if it has been replaced with cold water, thereby affecting the measurement taken.

Table 26 Example of milking machine wash program details recorded during a cleaning program review

Milking machine wash program assessment

Wash program reference number: *1*
Wash session being assessed: ☑ AM ☐ PM ☐ Other:

Cycle	Cycle description	Volume (litres)	Temp (°C)		Cleanser/Sanitiser	Measured dose (g or ml)	Comment	Pass ✓ or ✗
1	*Pre-rinse*	*200*	Start 35		*None, plain water*	*N/A*	*Rinse water very clear at the end*	☑ ☐
2	*Wash*	*200*	Start 87	Dump 63	*AM Alkali*	*400*	*20ml/10 L – as per label. Recirculated for 5.25 mins*	☑ ☐
3	*Final rinse*	*200*	Start 87	Dump 70	*None, plain water*	*N/A*	*Rinse straight to drain*	☑ ☐
4			Start	Dump				☐ ☐

Table 27 Example of bulk milking tank wash program details recorded during a cleaning program review

Bulk milk tank wash program assessment

Wash program reference number: bulk milk tank 1 *3* bulk milk tank 2

Cycle	Cycle description	Volume (litres)	Temp (°C)		Cleanser/Sanitiser	Dose (g or ml)	Comment	Pass ✓ or ✗
Bulk Milk Tank 1								
1	*Pre-rinse*	*150*	Start *40*		*Water*	*N/A*	*All foam removed*	☑ ☐
2	*Wash*	*120*	Start *64*	Dump *48*	*Tank Kleen Alkali*	*325*	*Recirc. time 6.5 mins. Dose was lower than label → 30ml/10 L*	☐ ☒
3	*Rinse*	*90*	Start *18*	Dump *18*	*Water*	*N/A*	*To drain*	☑ ☐
4	*Sanitise*	*120*	Start *18*	Dump *18*	*Tank Sans*	*200*	*Recirc. time 7 mins. Dose was lower than label → 20 ml/10 L*	☐ ☒
5								☐ ☐
Bulk Milk Tank 2								
1			Start					☐ ☐
2			Start	Dump				☐ ☐
3			Start	Dump				☐ ☐
4			Start	Dump				☐ ☐
5								☐ ☐

Energy and time review

Establish whether the times for recirculation of the wash and for the final rinse comply with the label directions and satisfy the contact time guidelines of 3–5 minutes (see page 31). For the wash cycle, determine the wash solution temperature when recirculation was stopped. Was it when the temperature dropped to 60°C (or what is specified on the detergent's label directions)? If the final rinse also used heat for sanitising determine that a contact time of at least 2 minutes was achieved.

If contact times satisfy the guidelines but the cycle temperatures are lower than recommended either the starting temperatures are too low, or the cycle volume(s) are insufficient, or a combination of both.

Turbulence review

There are two ways of assessing the turbulence created by the air injector; visual observations and more technical measurements.

1. VISUAL OBSERVATIONS

Flow through the cluster: check to see that cleaning solution is flowing through every milking unit (cluster). The flow should be turbulent and similar between clusters. Lack of turbulence despite apparently good flow may indicate a blocked/restricted air bleed in the cluster. Check and clear if necessary.

Slug speed can be estimated by following this method:

1. Determine the time, in seconds, from when the air injector turns on to when the slug enters the receiver.
2. Calculate the entire length of the milk line in metres.
3. Divide the length by the time to get the speed i.e. metres/second.

$$\textit{Slug speed} = \frac{\textit{milk line length (m)}}{\textit{time (s)}} = \textit{m/s}$$

Example: A 25-unit herringbone with a looped milk line.

Time taken from when the air injector first turns on to when the slug entered the receiver is 4.1s. The entire length of the milk line is 40m.

$$\textit{estimated average slug speed} = \frac{40m}{4.1s} = 9.8\ m/s$$

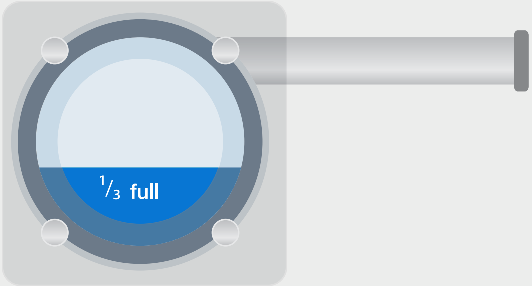
Slug flow in the milk line and into the receiver. During the wash cycle check the receiver to see that an effective slug is being produced. For it to be effective it must:

- Form and travel correctly. The rate of air admitted into the milk line by the air injector will determine the velocity of the slug and the time setting between air admissions determines slug volume. The air injector 'on-time' (length of time the air injector admits air for; typically between 3.0 and ~5.0 s) should cease the instant before the slug enters the receiver. If it ceases earlier than this then the slug will lose momentum and its 'quality' and subsequent cleaning effectiveness will be compromised. Also the section of milk line before the receiver may not be cleaned correctly.

Figure 38 A well-formed slug in the milk line

- If the air injector ceases (turns off) after the slug has entered the receiver, the entering air will destroy the cleaning solution's circular 'swirl' and reduce scrubbing action in the receiver. Again cleaning effectiveness will be compromised.
- The slug must have sufficient volume to fill around 1/3 of the receiver. The receiver must be no more than 1/3 full when the slug enters. The force and volume of the slug should be sufficient enough to cause the solution to 'swirl' around the entire receiver.

Figure 39 The receiver should be no more than a third full when the slug enters



Insufficient volume could be due to too short an interval between air admissions (air injector off-time is too short) or inadequate flow rate through the clusters to the milk line. Too much volume suggests the opposite situation.

The interval between slugs should be 20–30 seconds. This will allow between 12–15 slugs during the wash cycle – an ideal amount. On very large milking plants (70 units and more) this may be difficult to achieve.

Figure 40 A well-formed slug can create good turbulence (swirling action) and effective cleaning in the receiver.

Table 28 Example of records taken during a visual observation of a wash

CIP assessment

Air leaks at liner mouthpiece – jetter interface? If yes, which units? *18*	[x] Yes [ ] No
Cleaning solutions flow through every cluster? If no, which units? *18*	[ ] Yes [x] No

Vacuum levels & effective reserve

The working vacuum level is appropriate for this installation?	[x] Yes [ ] No
Vacuum level noted during the wash program (kPa)	*47*
The amount of effective reserve is appropriate for this installation?	[x] Yes [ ] No

Slug assessment

Slug flow	
Air injector working?	[x] Yes [ ] No
Slugs per wash cycle:	*13*
Estimated slug speed (m/s):	*10*
Volume of receiver just prior to slug entrance:	
less than ⅓ full	[ ]
⅓ full	[x]
½ full	[ ]
⅔ full	[ ]
greater than ⅔ full	[ ]

Slug enters the receiver:	
well after air injector turns off	[ ]
the instant after the air injector turns off	[x]
well before the air injector turns off	[ ]
Slug action in receiver:	
little or no swirling action. No wash solution entering the sanitary trap	[ ]
good strong swirling action with a little amount of wash solution entering the sanitary trap	[x]
little swirling action, receiver flooded with a large volume of wash solution entering the sanitary trap	[ ]
other:	[ ]

Table 29 Summary of slug characteristics and the factors by which they are influenced

Characteristic	Influenced by
Slug velocity	Air flow rate through the air injector. The greater the air flow rate the greater the velocity.
Slug volume	Off-time. The time interval between activation of the air injector. The greater the interval the greater the volume
Slug quality (how well formed the slug is)	On-time. The length of time the air injector is activated and admitted air. The on-time should cease the instant before the slug enters the receiver.
Receiver volume	Cleaning solution flow rate through the clusters and milk pump performance

2. TECHNICAL MEASUREMENTS

In addition to the visual assessment, the effectiveness of the slug flow dynamics and the flow rate through the milking units can be measured using a more technical approach. It requires a qualified technician with proper testing equipment which includes a two-channelled vacuum recording device.

Flow through the cluster: a visual inspection should be undertaken first to identify any clusters that may have uncharacteristic flow patterns. If there are any correct these first. To measure flow through the cluster by this method, you will need:

- ✓ test bucket
- ✓ large measuring jug
- ✓ stop watch.

a. Make a sketch of the layout of the wash system on a worksheet that also includes a table for recording flow rates through clusters.

b. Select approximately 10% of the clusters to test. Include clusters nearest to and farthest from where the wash suction line joins the jetter line. Mark these on the sketch.

c. Connect a test bucket to the first cluster to be tested. The connection to the milk line is best done with a tee inserted between the long milk tube and the milk inlet. Start the wash cycle.

d. As soon as water enters the test bucket (use the claw bowl as an indication) start the stopwatch.

e. Continue to collect water in the test bucket for at least 3 minutes after which the vacuum to the cluster can be shut off and the timing stopped.

f. Measure and record (in litres) the volume collected in the test bucket using the measuring jug. Record the elapsed time (convert minutes: seconds to decimal. For example, 3:30 = 3.5 minutes) in the table.

g. Repeat the test until all the clusters have been assessed.

h. Complete the worksheet to determine the flow rate through each cluster tested.

i. Check to see if all individual values are between 3–5 L/min for small dairies (up to 20 units) and 4–8 L/min for large dairies (especially those with weigh jar milk meters). If any are outside the guideline, investigation and retesting should be undertaken, particularly if flow rates are below the minimum.

j. Calculate the average flow rate by totalling the individual test values and dividing by the number of test values.

k. Divide the average flow rate value by 2 to determine the allowance. The allowance value is the maximum variability that is acceptable.

l. Check that all flow rate values fall within the allowance.

m. If test results indicate uniformity and sufficient flow rates no further testing should be required.

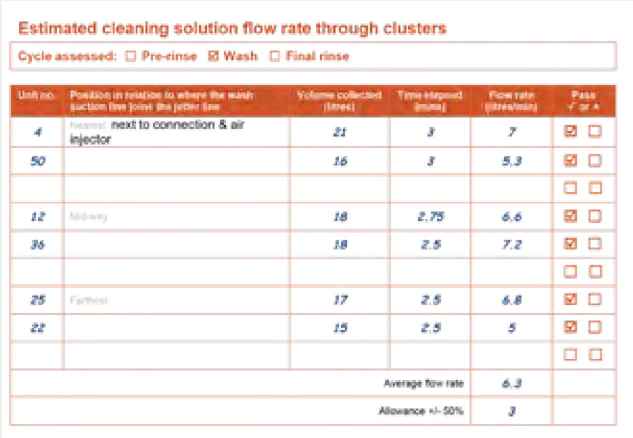
Figure 41 An example of a worksheet for recording flow rates through clusters

Estimated cleaning solution flow rate through clusters

Cycle assessed: ☐ Pre-rinse ☐ Wash ☐ Final rinse

Unit no.	Position in relation to where the wash suction line joins the jetter line	Volume collected (litres)	Time elapsed (mins)	Flow rate (litres/min)	Pass ✓ or ✗
	Nearest				☐ ☐
					☐ ☐
					☐ ☐
	Mid-way				☐ ☐
					☐ ☐
					☐ ☐
	Farthest				☐ ☐
					☑ ☐
					☐ ☐
			Average flow rate		
			Allowance +/- 50%		

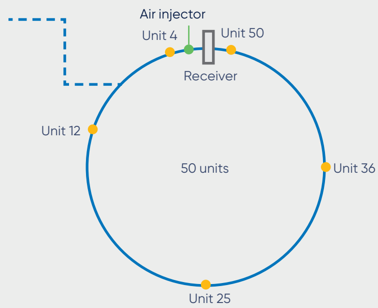
Figure 42 An example of a completed worksheet for recording flow rates through clusters



Estimated cleaning solution flow rate through clusters

Cycle assessed: ☐ Pre-rinse ☑ Wash ☐ Final rinse

Unit no.	Position in relation to where the wash suction line joins the jetter line	Volume collected (litres)	Time elapsed (mins)	Flow rate (litres/min)	Pass ✓ or ✗
4	Nearest: next to connection & air injector	21	3	7	☑ ☐
50		16	3	5.3	☑ ☐
					☐ ☐
12	Mid-way	18	2.75	6.6	☑ ☐
36		18	2.5	7.2	☑ ☐
					☐ ☐
25	Farthest	17	2.5	6.8	☑ ☐
22		15	2.5	5	☑ ☐
					☐ ☐
			Average flow rate	6.3	
			Allowance +/- 50%	3	



All clusters tested had flow rates between 4 and 8 L/min and the values were uniform. They satisfied the guidelines for flow rates.

Alternatively, a practical way to assess uniformity of flow between milking units is during herd test. When cleaning with the non-electronic herd test meters in place, check that the variation between the highest yield and the lowest is no more than 50%. Also, some milking machines with electronic milk meters may have capabilities to record and report on wash flow characteristics.

Slug flow dynamics can also be determined using a vacuum recorder:

1. Connect one channel of the vacuum recorder to a milk inlet near to where the slug is formed (close to the air injection point).
2. Connect the second channel to a milk inlet near where the slug returns to the receiver.
3. Measure the distance along the milk line between the two connection points.
4. Place the milking machine in cleaning mode and commence the cycle in which the air injector operates (the wash cycle).
5. Start recording the vacuum for both channels. As the slug passes the measurement points the vacuum level drops.
6. Stop recording after several cycles have been completed.
7. Determine the slug velocity and the vacuum drop from the recording.
8. The time (in seconds) between consecutive vacuum drops is used in the velocity calculation.

Choose the same point on the vacuum drops for both channels to determine the elapsed time.

Use the same calculation for slug speed as that given on page 56:

$$\textit{Slug speed} = \frac{\textit{milk line length (m)}}{\textit{time (s)}} = \textit{m/s}$$

9. Determine the vacuum drop by subtracting the minimum vacuum level from the average maximum level.

Compare this value with those given in **Table 30**.

Inadequate vacuum drop across the slug indicates that the slug is very short and/or excessive air is passing through the slug.

A slow rate of vacuum drop indicates that the slug is moving too slowly, usually because of excessive water in the pipeline or an excessively leaky milk/wash valve.

Table 30 Air flow requirements to achieve proper slug formation

Milk line diameter (mm)	Air flow rate (L/min)	Vacuum drop (kPa)
60	570–1,300	15–32
75	790–1,700	13–29
100	1,300–2,800	11–24

Chemical energy review

A chemical test kit is required to assess whether the chemical characteristics comply with the requirements for effective cleaning. The test should be conducted on cleaning solutions that have been made up but not used. The tests to conduct are given in **Table 31**.

Table 31 Chemical test parameters for cleaning solutions

Parameter	Range	Comment
Alkali wash pH level	11.5–12.5	If a non-chlorine alkaline detergent is used, adjust pH level to 12.5
Alkali wash	Milking machines: 800–2,000ppm	Based on soil load, refer to **Table 14** on page 31
Active Alkalinity	Bulk milk tank: 2000–3,000ppm	Based on soil load, refer to page 31
Chlorine level	Minimum 70ppm 100ppm for sanitising 140ppm for very heavy soil load	
Acid wash/ sanitiser pH level	2.5–3.5	

Before making adjustments to chemical dose rates it is imperative to verify that the 'presumed' chemical dose is actually being delivered. Capture the chemical as it is dispensed to make the verification.

Equipment drainage and maintenance review

At the end of each cycle the cleaning solution must drain freely and completely from the equipment. Retained cleaning solution can result from:

- milking equipment is under vacuum (vacuum pump continues to operate between cycles)
- drain valve failure (blockages, malfunction)
- insufficient drain time (relative to drain valve sizing)
- incorrect positioning of drain valve(s) or drainage point(s)
- lack of drain valve(s) or drainage point(s). and
- inappropriate pipeline slopes.

Equipment that is well maintained and whose components are routinely serviced should provide fewer opportunities for bacterial contamination and growth. A review of equipment testing and servicing is necessary to gauge the operational performance and provide evidence of component replacement. Things to look for are noted in the sections on Measurement of performance (page 12).

It is important to undertake a visual inspection of the equipment to ascertain the current condition of components and the effectiveness of cleaning. The objective is not to assess the performance of the components – although some inferences could be made by their presentation – but rather the ability of their milk contact surfaces to stay clean and to oppose microbial colonisation. Furthermore, it is an opportunity to inform the diagnosis of the problem, and help in developing the remedy.

Table 32 Example of cleaning solution test results

Milking machine cleaning solutions

Assessment should be conducted on cleaning solutions that have been made up but not used.

Alkali wash pH level	*12*
Alkali wash active alkalinity (AA) (ppm)	*1,600*
Chlorine level (ppm)	*N/A non-chlorinated alkali used*
Acid wash pH level	*2.5*
Acid sanitiser pH level	*N/A*

Visual inspections usually involve the dismantling of equipment. This can pose a challenge in many circumstances as it relies on the skills and know-how of the 'inspector', the tools required and on-hand, the complexity and layout of the equipment, the consent of the equipment's owner, and above all, the consideration of safety. The reality is that the components that are inspected are those where access is safe and easy, dismantling is simple and quick, and the skills and tools required are few. In addition, the owner is also comfortable and reassured that all equipment will be returned to the 'as found' condition.

Undertaking a visual inspection requires a systematic approach. It follows the path of the milk from the cluster to the bulk milk vat. Other components are also inspected even though they may strictly not be in contact with the milk; they may have been exposed to milk vapour or have had milk enter through a malfunction.

When inspecting a component four considerations are needed.

1. Is the surface clean or dirty? A clean surface is visually and physically free of any deposits, residues, stains etc.
2. If deposits are found, what sort of deposit is it?
3. What is the physical condition of the component? Perished, broken, cracked, etc.?
4. What is needed to restore/rectify the situation so that the component can be deemed clean?

A checklist for undertaking a visual inspection is provided in **Table 33**.

Table 33 Example of a visual inspection checklist

Equipment inspection

Inspect plant after a wash has completed and equipment has had time to dry

	Clean or Dirty		Deposit Found		Condition	Comments & actions required	Pass	
	✓ or	✗	✓ or	✗			✓ or	✗
Claw bowl	☑	☐	☑	☐	Rubber O-rings cracks	Replace all O-rings	☑	☐
Claw	☑	☐	☐	☐			☑	☐
Liner	☐	☒	☐	☐	Mouthpiece greasy	~20% greasy. Check liners are sealing during wash	☐	☒
Milk tube	☑	☐	☐	☐			☑	☐
Receiver	☑	☐	☑	☐	Sediment (grit) found on bottom	Ensure water is filtered to avoid debris entering wash.	☐	☒
Milk line	☑	☐	☐	☐		1st metre of each end inspected only	☑	☐
In-line components	☑	☐	☐	☐		Milk meters very clean	☑	☐
Sanitary trap	☑	☐	☑	☐	Sediment found on bottom	See above	☐	☒
Main receiver air line	☑	☐	☐	☐			☑	☐
Pulsator air line	☐	☒	☑	☐	Dust layers found, air filters missing	Clean out with warm soapy water. Install new filters.	☐	☒
Main air line	☑	☐	☐	☐			☑	☐
Interceptor	☑	☐	☐	☐			☑	☐
Milk pump(s)	☑	☐	☐	☐			☑	☐
Milk pump drain valve(s)	☐	☒	☑	☐	Milk residues	Dismantle & clean. Ensure valve is operating correctly	☐	☒
Milk purge connection	☑	☐	☐	☐			☑	☐
Filter(s)	☐	☒	☐	☐	Greasy inside head	Clean with an alkali soln. Check every few days.	☐	☒
Filter drain valve(s)	☑	☐	☐	☐			☑	☐
Plate cooler(s)	☑	☐	☐	☐			☑	☐
Milk delivery line	☑	☐	☑	☐	Seal on union loose	Dismantle & clean	☑	☐
Bulk milk tank outlet (1)	☑	☐	☐	☐			☑	☐
Bulk milk tank outlet (2)	☐	☐	☐	☐			☐	☐
Bulk milk tank 1	☐	☒	☐	☐	Greasy look on upper half of vat wall only at outlet end	Check hot water temp & alkali dose rate are correct. Check spray coverage from 1st agitator is adequate	☐	☒
Bulk milk tank 2	☐	☐	☐	☐			☐	☐
Jetter assemblies	☑	☐	☐	☐			☑	☐

Wash program review

Use the energy and time review details of the wash programs captured **(Table 24** and **Table 26**) to determine if:

- the three essential elements (pre-rinse, wash, and final rinse) are all present (refer to the section titled *Wash program* on page 34) and being executed correctly
- the detergents are matched to the available water quality and quantity
- the temperatures for each cycle meet the guidelines and label directions on the cleansers and sanitisers.

Combine the above information with that obtained from the visual inspection to ascertain if the program – the detergents used and the way they are used – is correct. Where there is a failure identify the corrective action(s). Corrective action may involve:

- change in dose rates
- change in cycle volumes (and subsequently, dose rates)
- change in detergents
- change in the frequency of use of detergents
- change in heating temperatures
- change in the number of cycles or the types of cycles
- change in cycle recirculation times, and/or
- change in wash program all together.

Wash routine review

A review of the wash routine is all about the execution of the wash program. Often the practice does not always synchronise with what should happen or what is documented to happen. Different staff can interpret or execute different parts of the wash program in different ways. It is worth comparing whether the wash program being *actually* executed is the same as what is documented on the 'wall sheet' and that which is conveyed during the investigation.

Wash Routine (page 43) to determine whether all the essential steps are being covered. This part of the review should uncover and then correct the discrepancies.

Table 34 Example of a wash program for a bulk milk tank

Cycle	Description	Comment
1st Cycle: Pre-rinse	Cold rinse, single pass	The temperature of the rinse water may be gradually increased to ~35–40ºC. Cycle volume ~2% of tank capacity. This is sometimes increased when excessive milk foam is present.
2nd Cycle: Wash	Hot wash. Alternating alkali/acid (pick-up/pick-up), 60–65ºC (starting temp), recirculate for 5–10 minutes then discard	Some systems may only perform a hot alkali wash. The acid function is incorporated into the sanitising cycle. The number of chemical dosing pumps may indicate the wash programs possible. For example, three dosing pumps may indicate alternating alkali/acid wash and a chemical sanitising rinse. Cycle volume ~1–2% of vat capacity.
3rd Cycle: Intermediate rinse	Cold rinse, single pass	Cycle volume ~1% of vat capacity.
4th Cycle: Sanitising rinse	Sanitising/acid sanitising rinse. Recirculate 4–6 minutes then discard	Temperature may be adjustable on some systems. Cycle volume ~1–2% of vat capacity.
5th Cycle: Final rinse	Cold rinse, single pass	Cycle volume ~1% of vat capacity.

Skills review

Some circumstances may require complex or regular changes to wash programs. It is easy to presume that the staff member responsible for executing the wash program has the necessary information and the relevant skills to ensure the dairy hygiene is maintained at all times. Some of the more common skill-related causes of deficient dairy hygiene are:

- Ability to discern one type of chemical detergent from another (e.g. alkalis from acids). This can result in a wash program comprising two alkalis or two acids. This may occur when a detergent runs out and a mistake is made with the replacement detergent (the labels can become illegible, further exacerbating the problem).
- Ability to correctly calculate the volume of water used. Many wash tanks don't contain volume indication markings, and their shapes (elliptical, trapezoid) can make calculating volumes difficult. Even with the common 200 litre or 110 litre chemical drums, difficulties arise when the volume is not easily matched (half or full drum). This can create two types of problems; a problem with dosing and dose rate, and a problem with water quantity (incorrect for requirements).
- Ability to correctly measure the correct dose. For example, sometimes the volumetric capacity of a container is interchanged with that of weight – a 250ml cup may be used to dispense 250g of powdered detergent.
- Ability to correctly make arithmetic calculations. For example, the label dose rate is 15ml/10 litre and the volume used is 240 litres.
- Reading and comprehension skills may also make it challenging for some staff to follow written instructions and label directions.

The skills and competency of the staff involved in executing the wash program must be accounted for and effort deployed to ensure the gap between the current and required skills is accommodated. This will involve anticipating where challenges and difficulties may arise and putting things in place to compensate.

It doesn't always have to involve staff training and development. Sometimes it might mean providing 'ready reckoner' charts, permanent markings on containers, language changes on instruction sheets (use of drawings), etc.

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04

APPENDICES

APPENDICES

APPENDIX 1. CHEMICAL REACTIONS

Saponification of milk fat by alkaline detergent

alkaline detergent	+	milk fat (insoluble)	→	soap (water soluble)
NaOH (aq) Sodium hydroxide	+	$C_{17}H_{35}COOH$ (s) stearate ion	→	$C_{17}H_{35}COO$-Na+(aq) calcium stearate

Acids dissolve mineral deposits

lime deposit	+	acid	→	dissolved minerals	+	gas	+	water
$CaCO_3$ (s)	+	2H+(aq)		Ca^{2}+ (aq)	+	CO_2(g)	+	H_2O(l)

Hard water scum formation

hard water	+	milk fat (insoluble)	=	soap (water soluble)
Ca^{2}+ (aq) calcium ion	+	$2C_{17}H_{35}COO$-(aq) stearate ion	→	$Ca(C_{17}H_{35}COO$-)2 (s) $\downarrow$ calcium stearate

The reaction of alkaline detergents with hard water

hard water	+	detergent					+	precipitate
$Ca(HCO_3)_2$ hard water ions	+	2NaOH caustic soda	→	Na_2CO_3 sodium carbonate	+	H_2O water	+	$CaCO_3$ $\downarrow$ calcium carbonate
$MgSO_4$ hard water ions	+	2NaOH caustic soda	→	Na_2SO_4 sodium sulphate			+	$Mg(OH)_2$ $\downarrow$ magnesium hydroxide
$CaSO_4$ hard water ions	+	Na_2CO_3 sodium carbonate	→	Na_2SO_4 sodium sulphate			+	$CaCO_3$ $\downarrow$ calcium carbonate

The formation of hot water scale

hard water ions		heat				precipitate
Ca^{2}+ (aq), $2HCO_3$ (aq)	→	H_2O (l)	+	CO_2 (g)	+	$CaCO_3$ (s) $\downarrow$
Mg^{2}+ (aq), $2HCO_3$ (aq)	→	H_2O (l)	+	CO_2 (g)	+	$MgCO_3$ (s) $\downarrow$

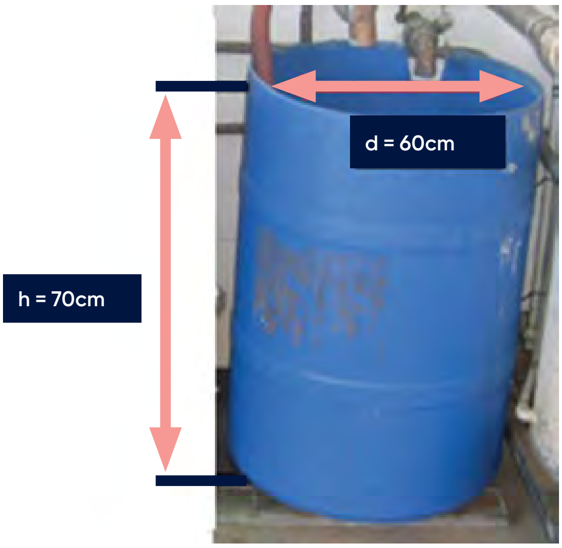
Sequestering of hard water to prevent scum formation

hard water	+	TPP in detergent	→	no precipitation
$2Ca^{2}$+ (aq) calcium ions	+	$P_3O_{10}^{5-}$(aq) tripolyphosphate	→	$Ca_2P_3O_{10}$ (aq) water soluble

APPENDIX 2. MEASUREMENTS AND CALCULATIONS

The aim of this section is to give an outline of how to take measurements when you visit a problem farm. Don't assume the farmer knows how much water is being used during each wash cycle.

Figure 43 Measuring a cylindrical drum to calculate the volume



The volume of a *cylindrical* wash drum in litres:

$$V = \frac{0.78\ d^2h}{1000}$$

Note: $d^2 = d \times d$

Where: V = Total Volume (L)

d = diameter (cm)

h = height (cm)

$$0.78 = \frac{2}{4} \quad \text{from the formula: Volume} = \frac{\pi\ d^2}{4}$$

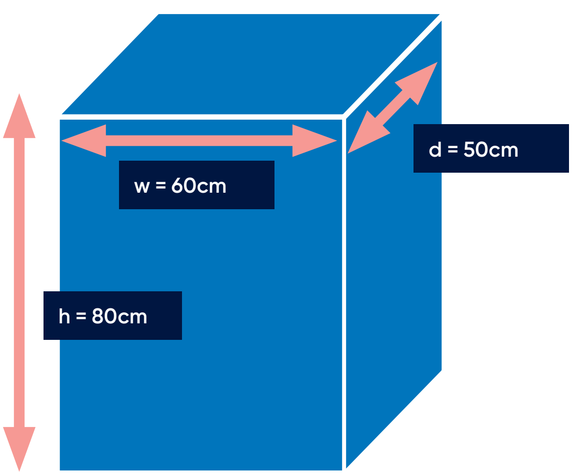
Example

What is the volume of a wash drum with a diameter of 60cm and a height of 70cm?

$$V = \frac{0.78\ d^2h}{1000}$$

$$\text{Volume} = \frac{0.78 \times (60\text{cm} \times 60\text{cm}) \times 70\text{cm}}{1000} = 197\ \text{L}$$

Figure 44 Measuring a square or rectangular drum to calculate the volume



The volume of a *rectangular or square shaped* wash drum in litres:

$$V = \frac{h \times w \times d}{1000}$$

Where: V= Volume (L)

h = height (cm)

d = depth (cm)

w = width (cm)

Example

What is the volume of a wash drum that has; a height of 80cm, a depth of 50cm and a width of 60cm?

$$V = \frac{h \times w \times d}{1000}$$

$$V = \frac{80 \times 60 \times 50}{1000}$$

$$V = 240\text{L}$$

APPENDIX 3. THERMODURIC, THERMOPHILIC AND PSYCHROTROPHIC BACTERIA

Thermoduric bacteria

Thermoduric bacteria can survive temperatures above their optimal growth temperatures. For milk and diary products, such bacteria commonly survive pasteurization, and include *Micrococcus, Streptococcus, Lactobacillus, Bacillus species*, and occasionally gram-negative rods. Contamination sources include poorly cleaned or sanitised milk collection or processing equipment. These bacteria contribute to high Standard Plate Counts on pasteurized milk (lab pasteurization counts: LPC counts). The thermoduric count is a reflection of utensil sanitation, and a means of detecting sources of organisms responsible for high counts in the final product.

Thermophilic bacteria

Thermophilic bacteria applies to those which grow in milk at temperatures of 55ºC or higher, including pasteurization, 62.8ºC. Thermophilic bacteria include Bacillus species, which enter milk from various farm sources or poorly cleaned processing plant equipment. In milk held at high temperatures for long periods, thermophilic bacteria numbers can rapidly increase and cause flavour defects and/or unacceptable bacteria load. Thermophilic bacteria counts are obtained through a Standard Plate Count incorporating appropriate incubation temperature.

Psychrotrophic bacteria

Microorganisms which thrive in low-temperature environments are psychrophilic, meaning cold-loving. Psychotropic bacteria are those that grow rapidly at or below 7ºC and include sub-species of *Pseudomonas, Flavovacterium, Alcaligenes, Acinetobacter* and *Bacillus*. This group is generally non-pathogenic, but may cause various off-flavours such as fruity, stale, bitter, putrid and rancidity, in dairy products. Psychotropic bacteria rarely occur in the udder. Bacteria numbers in milk depend upon the sanitary conditions prevailing during production, as well as the time and temperature of milk prior to processing. The influence of psychotropic bacteria on the shelf life of pasteurized milk will depend primarily on the number present after packaging, growth rates during the storage period, and the biochemical activity of the organisms.

The key concept is cleaning and sanitation!

Source: **http://www.iandalab.com/bulletins/bulletin07.htm**

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