Green Cleaning

A Handbook on Designing an Environmentally Friendly Milking Machine CIP System

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Working Version

Acknowledgements

I wish to acknowledge the following publications were valuable resources and were extensively referred to in the preparation of this almanac.

Dairy hygiene and detergent handbook (2000) Alfa Laval Agri, Australia

Allinson G, Dyer M (2007). Closing the Loop: An holistic approach to the management of dairy processor waste streams. Progress Report 8 (Final Report). Department of Primary Industries, Queenscliff, Australia.

Weeks M, Issa J, Warren S, Knight G (2004) Closing the Loop: An holistic approach to the management of dairy processor waste streams. Review of Products and Processes to reduce Sodium Usage in Dairy CIP Manufacturing Procedures. Milestone Report 1. Department of Primary Industries, Queenscliff, Australia.

Abbreviations & Definitions

CIP	Cleaning-in-Place Defined as the circulation of cleaning chemicals through machines and other equipment in a cleaning circuit (Bylund 1995 in Eide et al. 2003). It is an automated or semi-automated procedure where cleaning chemicals are circulated through the milk contact sections of the milking machine without dismantling the equipment.
CTL	Closing the Loop A project investigating an holistic approach to the management of dairy processor waste streams.
Soil	Milk based residues that deposit onto the surface of milking machine equipment
NRE	Natural Resources & Environment
OH&S	Occupational Health & Safety
Recirculate	The repeated circulation of cleaning solutions (caustic or acid) through the milking machine milk contact surfaces.
Re-use	To reapply a cleaning solution in a CIP process.
Reclaim	To adequately recover used active cleaning chemicals from cleaning solutions that would have typically gone to waste.

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Introduction

The principles of cleaning milking machines have not changed over the last twenty years or more. Dairies around the world apply these same principles, albeit with localised interpretations. What has changed is the manner in which milking machines are cleaned. Cleaning in place (CIP) has been for at least the last 15 years the universal way to wash milking machines in Australia. It is labour and water efficient and much safer than the alternatives of "reverse flow" and "bucket cleaning".

Technology and automation have also helped to make cleaning easier and more consistent. Modern dairies now use automated systems that control chemical dosing, water volumes, wash cycles, temperatures as well as monitoring and alerting on system performance. It is a vast difference to the bucket cleaning method employed only 15 years ago.

This change in the way milking machines are cleaned, as opposed to principles of cleaning, is reflected in the literature. Research over the last decade has predominantly focused on refining cleaning system performance, for example, improving slug flow conditions, and improving the analysis and interpretation of cleaning assessment procedures.

The thrust of the Green Cleaning project is to inject the principles of energy and water efficiency into the CIP systems used in Australian dairies. The project will develop an energy efficient re-use CIP system that can be used as a product in its own right or preferably as a platform for exploitation by the commercial sector.

Either way the project's ultimate aim is to have available "on the shelf" CIP product(s) that will reduce the environmental footprint of Australian dairy farms.

Principles of Cleaning

Regardless of the techniques employed, or the layout of the milking equipment, there are six key elements that are fundamental to the 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 (Romney, 1990).

Table 1 - Principles of Cleaning (Romney, 1990)

Cleaning Principle	Explanation	Opportunities for reducing environmental footprint
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.	Wash & rinse cycles are reclaimed and re-used. Potable quality water reduces chemical concentrations.
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 (Kumar 1998). Temperature is also used as a sterilising agent. **Kinetic energy** (turbulence) primarily provided by the air injector (flushing pulsator). 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.	Heat water using renewable & recaptured energy. Use a system that requires water being heated to lower temperatures. Minimise thermal losses.
	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 detergents are employed to clean milking equipment. Alkaline detergents: Used to remove the organic deposits, milk fats and proteins; Acid detergents: Used to remove the inorganic deposits, minerals. Acid based sanitisers. Primarily used to sanitise.	Use chemicals that contribute lower levels of contaminations of dairy shed wastewater. Chemicals with lower embodied energy. Fewer chemical types (instead of acids, alkalis & sanitisers all being used). Chemicals with very low – or zero – residues, eliminating the need for rinsing
Time	Contact time between the cleaning solution and the surface to be cleaned.	System that minimises equipment running time.
Drainage	Ability of solutions & residues to be drained from the equipment, reducing contamination.	Rapid drainage reduces heat loss between cycles & shortens cleaning time.
Machine Maintenance	Routine maintenance of milking machine components and system performance.	Reduce requirement for “heavy duty” cleaning.

Effective CIP requires the use of a combination of alkalis, acids and sanitisers to remove organic, inorganic and microbial fouling deposit from a dairy process (closing the loop, report 1 page 29).

Water

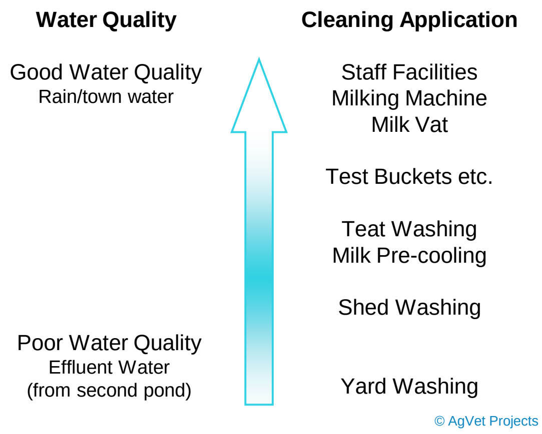
Water Quality

Two commonly used indicators of water quality for the dairy are hardness content and microbial contamination. The best quality water should be used for cleaning the milking machine and milk vat. It should be potable water – suitable for human consumption.

Water Hardness

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 corrosion of hot water heating elements and other milking equipment.



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 below. The softer the water is the better its quality and the greater its range of uses.

Table 2 - Water Hardness Classifications

Rating/Classification	CaCO3 (mg/L*)
Soft	0 to 50
Moderately Soft	50 to 100
Slightly Hard	100 to 150
Moderately Hard	150 to 200
Hard	200 to 450
Very Hard	450+

Source: AQWEST. http://aqwest.wa.gov.au/about/faq.asp *1 mg/L = 1 ppm $CaCO_3$

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.

Types of water treatment systems available to are beyond the scope of this project.

Water Quality Parameters

The water quality to use in a re-use system should have a hardness of <150ppm ($CaCO_3$) and an iron level of less than 0.5 ppm.

Water Quantity

The quantity of water required to achieve adequate surface contact and minimise thermal loss is 6-8 l/unit. Volumes will need adjustment to accommodate individual circumstances – such as long milk delivery lines.

Table 3 - Total volume of water per wash

No. Units	Total Volume Of Water Per Wash* (litres)
20	480
24	575
30	720
40	840
50	1050
60	1260

*Assumes 3 cycles per wash (pre-rinse, detergent wash, sanitise).

As the number of milking units increase with growing herd sizes access to potable quality water for many Australian dairy farms will become increasingly difficult. CIP systems that can reduce the daily volume requirements will become a necessity.

Cleaning Procedure

Existing Cleaning Cycles

In Australia

Table 4 - Existing Australian cleaning cycles

Cycle 1	Cycle 2	Cycle 3	Comments
Post-milking rinse. 35-38 °C, single pass	Hot wash. Alternating alkali/acid, 85 °C (starting temp), recirculate for 3-5 mins, discard above 60 °C.	Hot water rinse. Single pass.	Predominant procedure. Approximately 50% of farms employ a cold water rinse in cycle 1. Cycle 3 may be substituted by a warm acid sanitiser recirculating rinse
Post-milking rinse. 35-38 °C, single pass	Warm-hot acid sanitising wash. Recirculate for 3-5 mins. Hot alkali wash is substituted ~2 milkings per week.		Used when water availability is limited and/or water hardness exceeds 700 ppm $CaCO_3$.

In New Zealand

Table 5 - Existing New Zealand cleaning cycles

Cycle 1	Cycle 2	Cycle 3	Comments
Post-milking cold rinse., single pass	A.M. milking. Cold acid sanitising wash, single pass. Hot alkali wash, 80-85°C, discard above 60°C, is substituted ~2 -3 mornings per week. P.M. milking. Cold acid sanitising wash, single pass.	Cold acid sanitiser when alkali wash is used.	Acid dominant wash cycle. Alkali used ~2-3 mornings a week. Recirculation of hot wash only. Cycle 3 occurs only after hot alkali wash.

In the United States

Table 6 - Existing US cleaning cycles

Cycle 1	Cycle 2	Cycle 3	Cycle 4	Comments
Post-milking rinse. 35-43 °C, single pass	Hot wash. Chlorinated alkali, 70-75 °C, recirculate for 6-10 mins, discard above 55 °C .	Cold acid (pH<3) rinse. Single pass, allow to drain	Sanitising rinse prior to milking. Single pass, allow top drain.	Acid frequency is dependent on water hardness.

In Europe

Table 7 - Existing European cleaning cycles

Cycle 1	Cycle 2	Cycle 3	Comments
Post-milking rinse. 35-43 °C, single pass	Hot wash. Chlorinated alkali, 80-85 °C, recirculate for 6-10 mins, discard above 60 °C.	Cold rinse. Single pass.	Acid frequency is dependent on water hardness.

In China

Table 8 - Existing Chinese cleaning cycles

Cycle 1	Cycle 2	Cycle 3	Comments
Post-milking cold rinse, single pass.	Hot wash. Alternating alkali/acid. Chlorinated alkali	Cold rinse. Single pass.	Hot acid wash every third wash (2 alkali then acid). Use of a sanitising cycle is not commonly practiced. Where it is practiced (southern China), a chlorine based sanitiser is employed prior to milking.

Chemicals

Types/roles

To be researched by the Industry partners.

CIP Mechanics

Turbulence

Successful cleaning of milklines relies on liquid slug formation to provide adequate turbulence and cleaning action. This is achieved with the use of an air injector. Slug velocities of 6-12 m/s (typically 10-15 m/s) are necessary. Vacuum pump capacity, vacuum level and milk line fill rate will influence the slug performance.

Vacuum pump capacity

The milking machine's effective reserve and pump capacity should satisfy the Australian industry's guideline which specifies a minimum requirement.

Effective Reserve = 800 + 20n (up to 40 units) + 10n (>40 units)

Pump Capacity = Effective Reserve + 50 n (where n = number of milking units).

The table below provides a guide to the minimum effective reserve & pump capacity requirements for different milking machine sizes.

Table 9 - Minimum requirements for effective reserve and vacuum pump capacity for different sizes of milking machines

Number of milking units	Minimum Required Effective Reserve (litres/minF)	Required Pump Capacity (litres/minF)
16	1,120	1,920
18	1,160	2,060
20	1,200	2,200
22	1,240	2,340
24	1,280	2,480
26	1,320	2,620
28	1,360	2,760
30	1,400	2,900
32	1,440	3,040
36	1,520	3,320
40	1,600	3,600
44	1,640	3,840
50	1,700	4,200
60	1,800	4,800
70	1,900	5,400
80	2,000	6,000

Drainage

The milking equipment should be capable of swift and complete drainage. This of particular importance in CIP re-use systems, where contamination from the previous wash cycle can compromise the effectiveness of the wash solution in the subsequent cycle.

Condition of components

Regular servicing and maintenance of milking machine components will reduce the risk of ineffective cleaning. Milk contact consumables (liners, hoses, tubing, diaphragms, seals etc.) should be replaced as per manufacturer's recommendations. Usually, milk contact rubberware should be replaced every 12 months. Nitrile-based liners should be replaced by 2,500 cow milkings or every six months, whichever comes first.

Performance Monitoring Systems

Dairy factory results

Dairy factories provide daily results of the quality of their suppliers' bulk milk. Routine testing is undertaken for somatic cell counts, microbial contamination (TPC, Bactoscan, thermoduric count), sediment, antibiotics etc. Total Plate Count (TPC) or Bactoscan count and thermoduric count are the two tests used as an indication of milking equipment hygiene. The tests are understood by the majority of dairy farmers and used as a milk quality management tool.

Table 10 - Example of milk quality criteria thresholds used by Victorian dairy factories

Parameter	Premium Grade	Standard Grade	Sub-standard Grade
Total Plate Count (cfu/ml)	<20,000	20,000 – 50,000	>50,000
Bactoscan	≤80,000	>80,000 - ≤200,000	>200,000
Thermodurics (cfu/ml)	<2,000	2,000 – 5,000	>5,000
Thermophiles (cfu/ml)	<1,000	1,000 – 5,000	>5,000

Manual/visual procedures

Physical and visual inspection of milk contact surfaces remains an integral tool to evaluate cleaning effectiveness. Inspection involves systematic dismantling of milking machine components to identify any deposits. The type of deposit (protein based, fat based, mineral based) and where it is located will highlight cleaning performance deficiencies.

Commercial Diagnostic Tests

ATP bioluminescence is diagnostic test that can be used to estimate the cleanliness of surfaces. Its application and usefulness in the dairy industry was reviewed by Griffiths (1993). It is extensively used throughout the food and health care industries and scores of ATP test kits are commercially available. However, the extreme variability of farm environmental conditions and test results limit their suitability for assessing the hygiene status of milking machine equipment (Reinemann, personal comms; Vilar *et. al.*, 2008).

Energy Inputs

On most Australian dairy farms the thermal energy used for cleaning the milking machine is derived from electric hot water services (HWS). Typically there are two types of hot water systems: a mains pressure domestic HWS that heats water to 60-65^{o}C which is used for cleaning the milk vat; and an un-pressurised HWS that heats water to 95^{o}C used for cleaning the milking equipment.

Vat refrigeration heat reclaim systems are used on a small proportion of farms. These systems can heat water to about 65^{o}C; however the quantity of water (280-400 litres) heated and the temperatures achieved are dependent on the amount of milk to be cooled and the amount of "work" required of the refrigeration system. Vat washing is typically the end use for this heated water.

For many dairying areas of Australia, solar hot water systems are an energy efficient way obtaining hot water. Appropriately sized solar hot water systems can reduce electricity demand by 50% and more.

Recent (2009) incentive schemes made available through the Federal Government have led to the sale of heat pumps to dairy farms. These heat pumps offer a more energy efficient means of heating water used for cleaning milking machines. Water can be heated to 55-60^{o}C using a heat pump. Therefore, typically they are used as a means of pre-heating the water prior to it entering the dairy's hot water service.

CIP Prototype

Feature Prerequisites

The CIP prototype has been designed to incorporate the following features:

Intuitive user interface

- Easy to read and navigate display
- Intuitive menu and function selection
- Clear and simple descriptions of step progression
- Fault notification with simple advice on corrective actions.

Wash program flexibility

- Ability to customise wash programs to suit specific chemicals or milking equipment requirements – including types of cycles, cycle order, number of cycles and the temperature of each cycle
- Ability to run different programs (or the same program) at specific milking times or on specific days
- Common method of determining chemical dose rates and concentration.

Water efficient

- Re-use water as many times as possible
- Maximise recovery of cleaning solutions after each cycle
- Replenish with potable quality water only.

Chemicals

- Use chemicals that require low cleaning temperatures (30-40^{o}C)
- Chemicals can be reclaimed and re-used
- Have low embodied energy and low environmental impact.

Energy

- Use renewable energy for heating water
- Capture heat where possible
- Minimise thermal losses through good design and effective insulation.

Construction

- Use components that are readily accessible
- Design the system so that it is universally applicable (“one size fits all”) to gain economies of scale, reduce replication and minimise inventory levels.

Installation, service & maintenance

- System is easy to install, service and maintain.

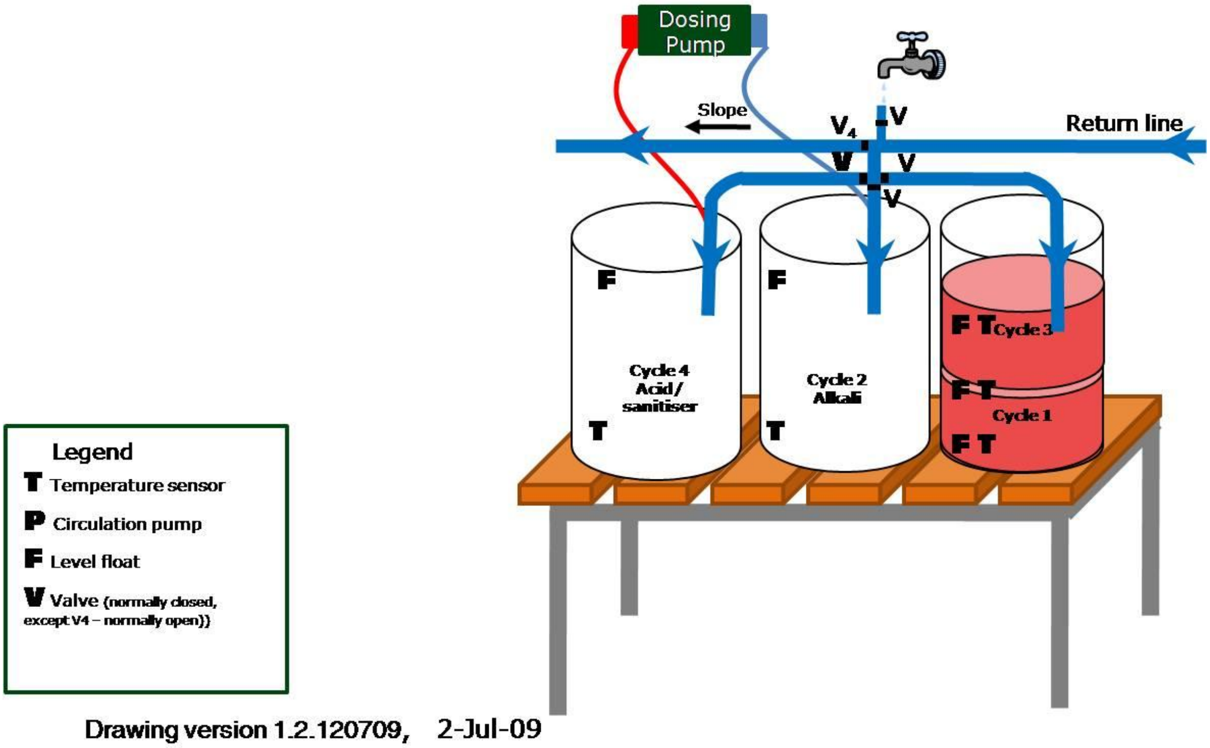
OH & S

- Risks to operators and service personnel are minimised or eliminated.

Design

The following schematic diagrams detail the layout of the various components of the prototype CIP system. It is important to note that additional components were included in the design to accommodate flexibility and to conduct research.

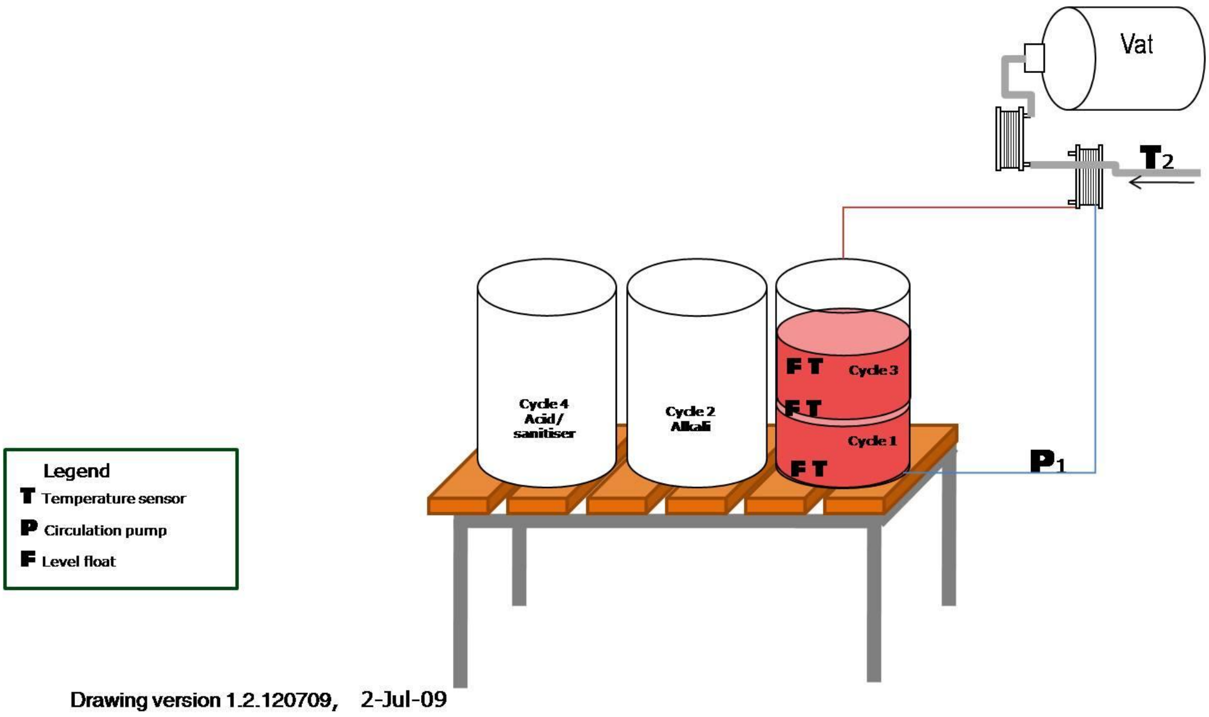
Dosing & Filling



Design particulars

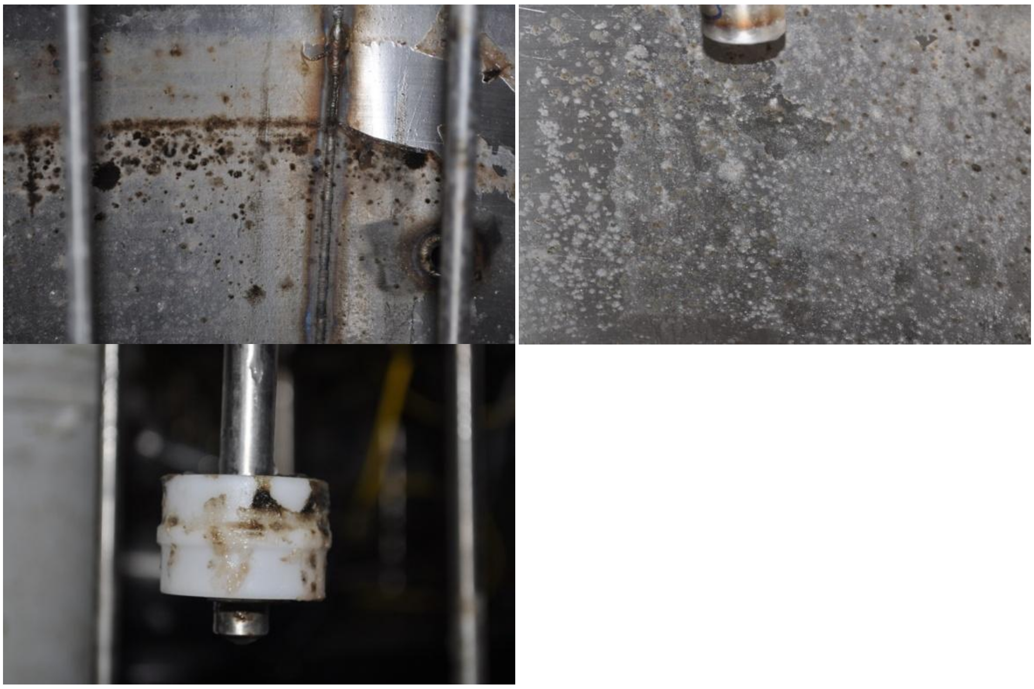
- 50mm SS pipes.
- Valves to be the same size as the pipes – 50mm.
- Valves to be installed as close as possible to an intersection to ensure proper drainage and minimise cross-contamination of liquids.
- Valves used on prototype are pneumatically operated and are normally closed. The drainage valve (V4 normally open) is vacuum operated.
- Slope direction of return line should fall towards the drain valve (V4).
- Pipes can enter via the wall of the tanks rather than through the lid. This allows easier access to the inside of the tank.
- Each return pipe terminates approximately 1/3 from the top of the tank.
- Dosing tubes are connected to a ss nipple on the relevant return line entering the tank (downstream of the valve).
- Fresh water flow rate should be capable of filling the tank within 10 minutes – at least 60 l/min.
- A common fresh water supply is used to economise on the number of valves.

Heating the Rinse Cycle



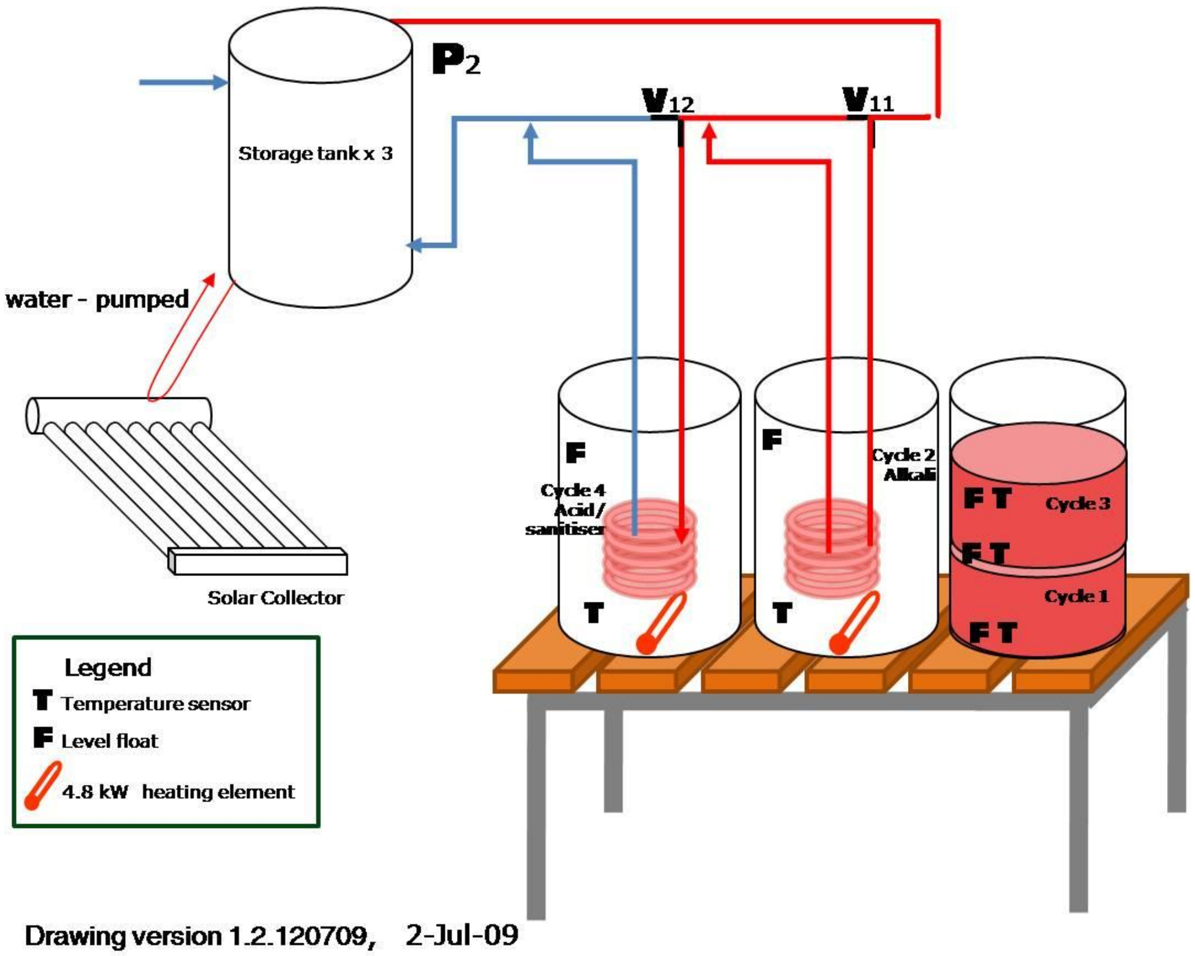
Design particulars

- Circulation pump is gravity fed
- Water is circulated through a dedicated plate cooler or the first bank of a double-bank plate cooler.
- Flow rate through the "heating" plate cooler should have the same sized milk inlet pipes as the existing plate cooler.
- The plate cooler should be matched to the flow rate capacity of the milk pump(s).
- Pipe sizes should satisfy circulation pump requirements – 32-38mm pipes will be usually adequate.
- The bottom temperature sensor is used as reference water temperature.
- The rinse water has achieved a temperature within 1^{o}C of the milk temperature. To date, a rinse water temperature of 32^{o}C has been achieved.
- Ensure the rinse tank is enclosed and well insulated. Overnight temperature losses of only 2-3^{o}C have been recorded.
- Being a warm dark environment will encourage the growth of bacteria and other microbes (see pictures below). This can be overcome by once-a-day dosing with a sanitiser containing rinse additive.



The rinse tank: moulds and bacteria will grow in the warm, dark and wet environment. This was overcome by daily dosing with a rinse additive containing a sanitiser.

Heating the Wash Cycle



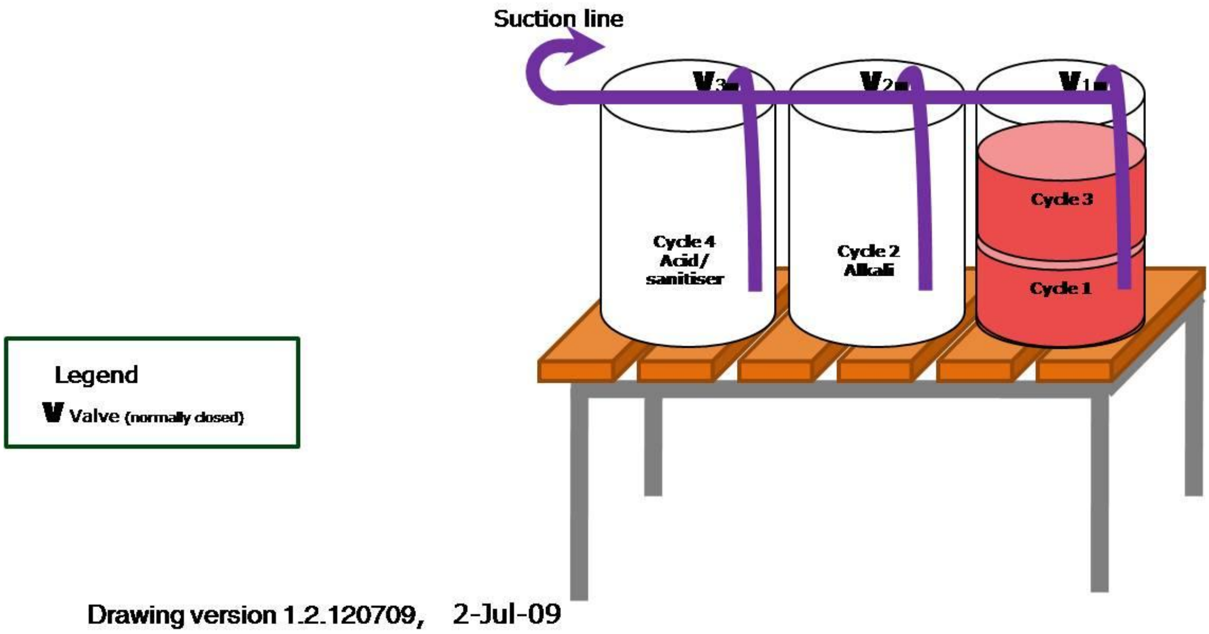
Design particulars

- Renewable energy source can be from solar, heat reclaim, geo-thermal.
- The water used as the heating source flows through a closed circuit.
- The stainless steel heating coils inside the chemical tanks are 25mm ID. There are four coils (see picture below).

- The heated water should travel the alkali tank first as the alkali detergent is the most temperature dependant.
- The wash solutions in the chemical tanks have been heated to within 5°C of the temperature in the solar storage tanks.
- Pipes can enter via the wall of the tanks rather than through the lid. This allows easier access to the inside of the tank.

A 4.8kW heating element is installed at the base of the tank to provide supplementary heating if required. It is a low watt density Incoly 825 element.

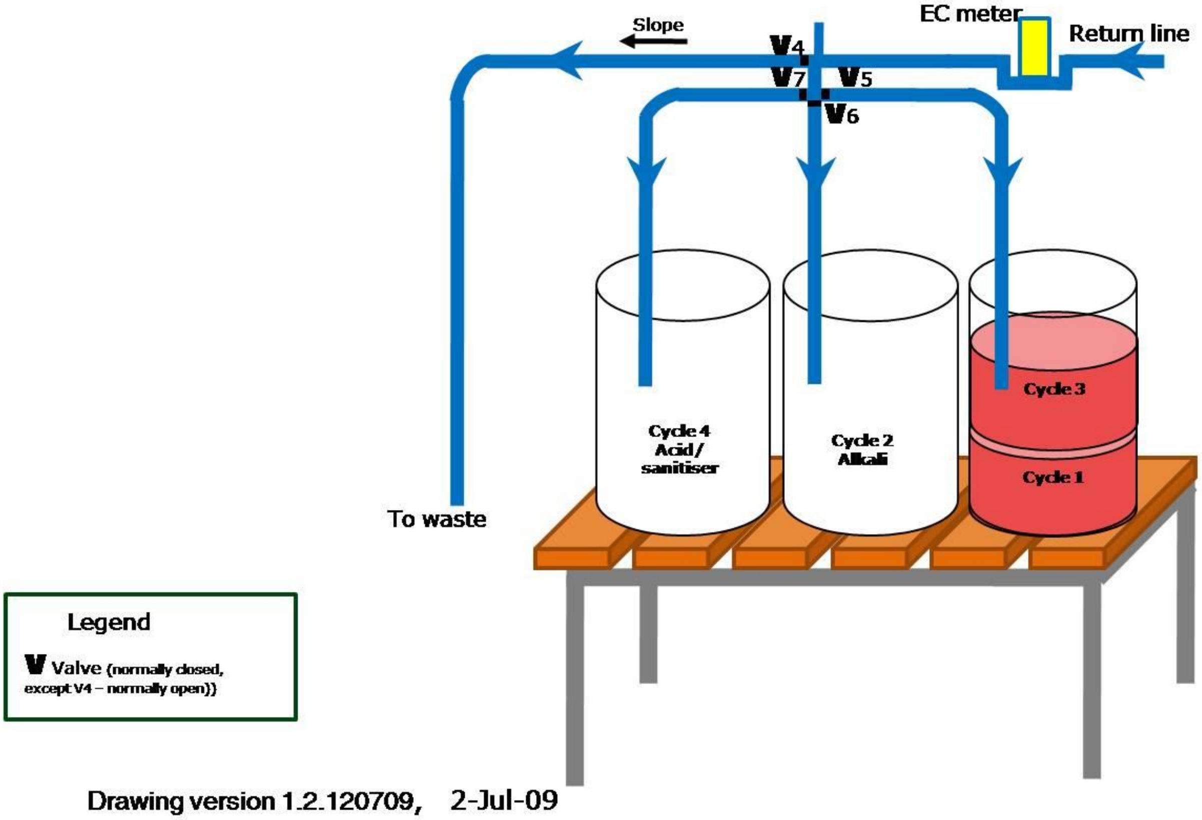
Wash Suction Line



Design particulars

- 50mm SS pipes.
- Valves to be the same size as the pipes – 50mm.
- Valves to be installed as close as possible to an intersection to ensure proper drainage and minimise cross-contamination of liquids.
- Valves used on prototype are pneumatically operated and are normally closed.
- Line should fall towards the plant.
- Pipes can enter via the wall of the tanks rather than through the lid. This allows easier access to the inside of the tank.
- Each return pipe terminates approximately 3/4 from the bottom of the tank.
- The pipes entering the tanks should be higher than the conveyance pipe. These pipes on the prototype have 180 degree bends to minimise the chance of cross-contamination.

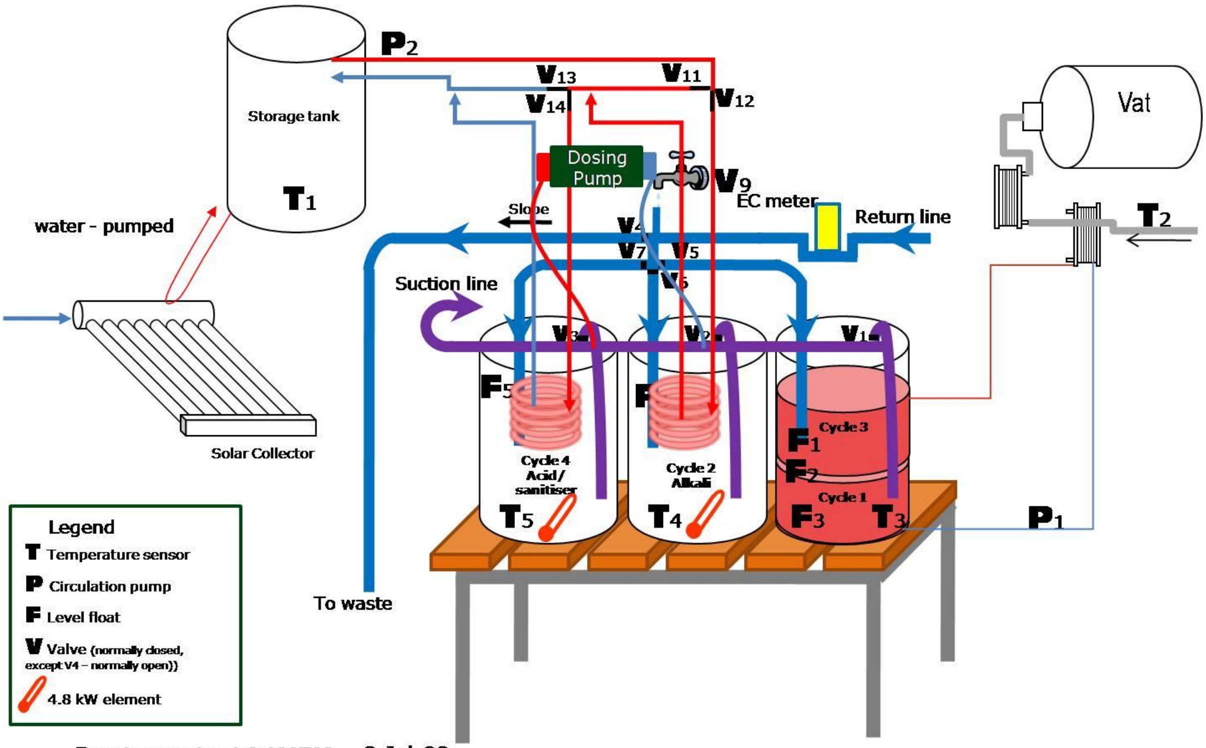
Wash Return Line



Design particulars

- 50mm SS pipes.
- Valves to be the same size as the pipes – 50mm.
- Valves to be installed as close as possible to an intersection to ensure proper drainage and minimise cross-contamination of liquids.
- Valves used on prototype are pneumatically operated and are normally closed. The drainage valve (V4 normally open) is vacuum operated.
- Slope direction of return line should fall towards the drain valve (V4).
- Pipes can enter via the wall of the tanks rather than through the lid. This allows easier access to the inside of the tank.
- Each return pipe terminates approximately 1/3 from the top of the tank.
- The probe of the EC meter should sit in U-section of pipe.

The Complete System



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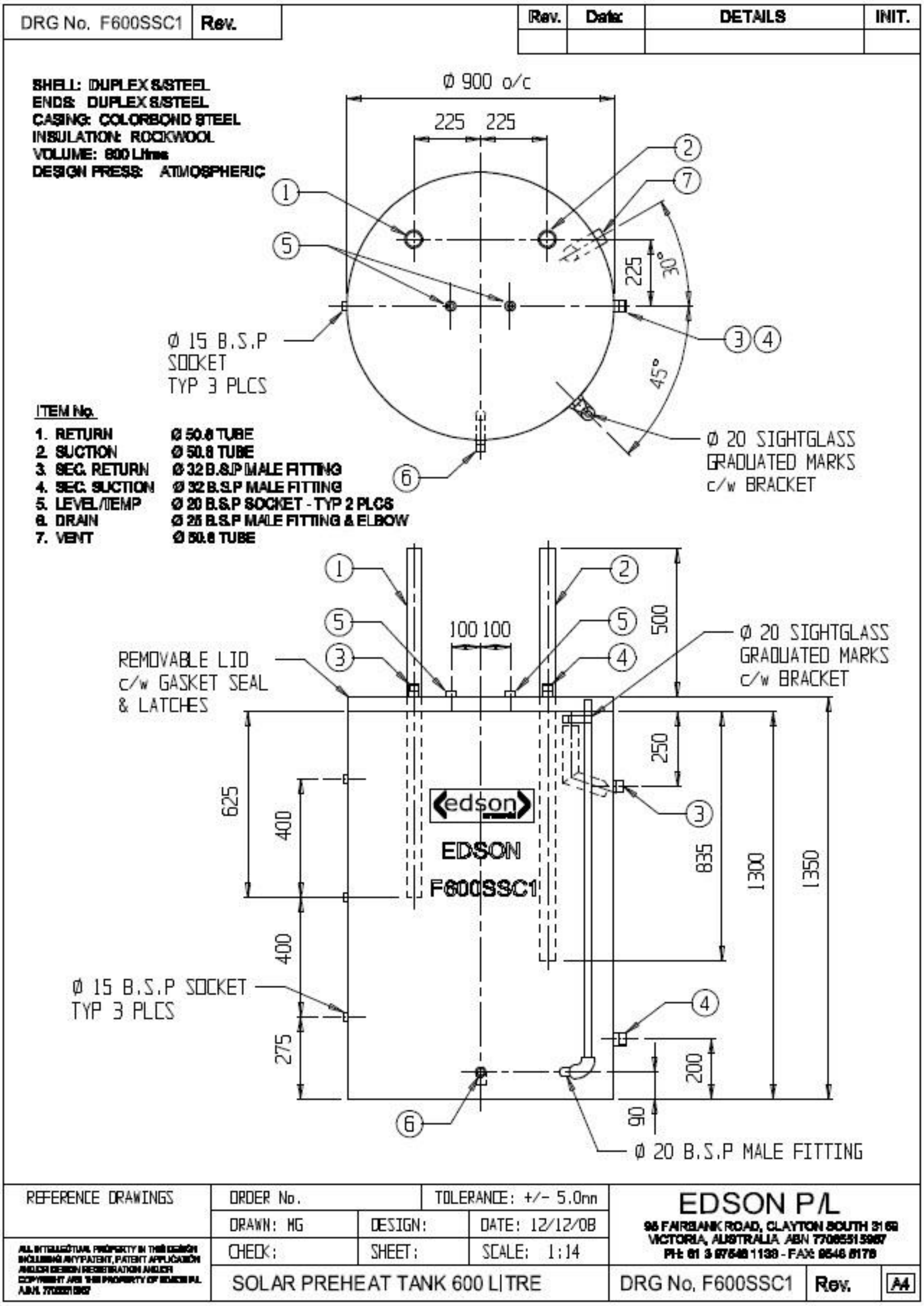
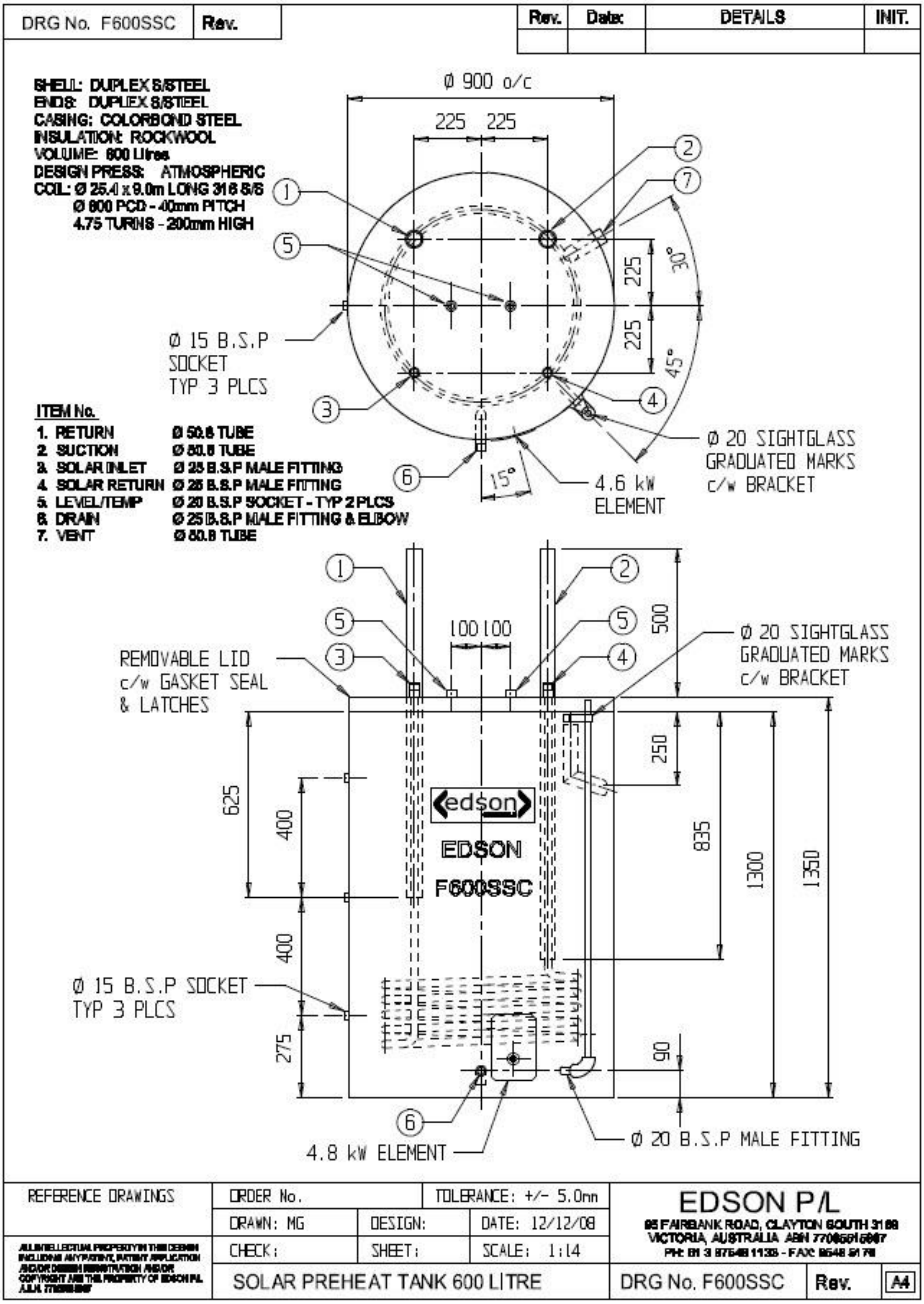
The Rinse Tank



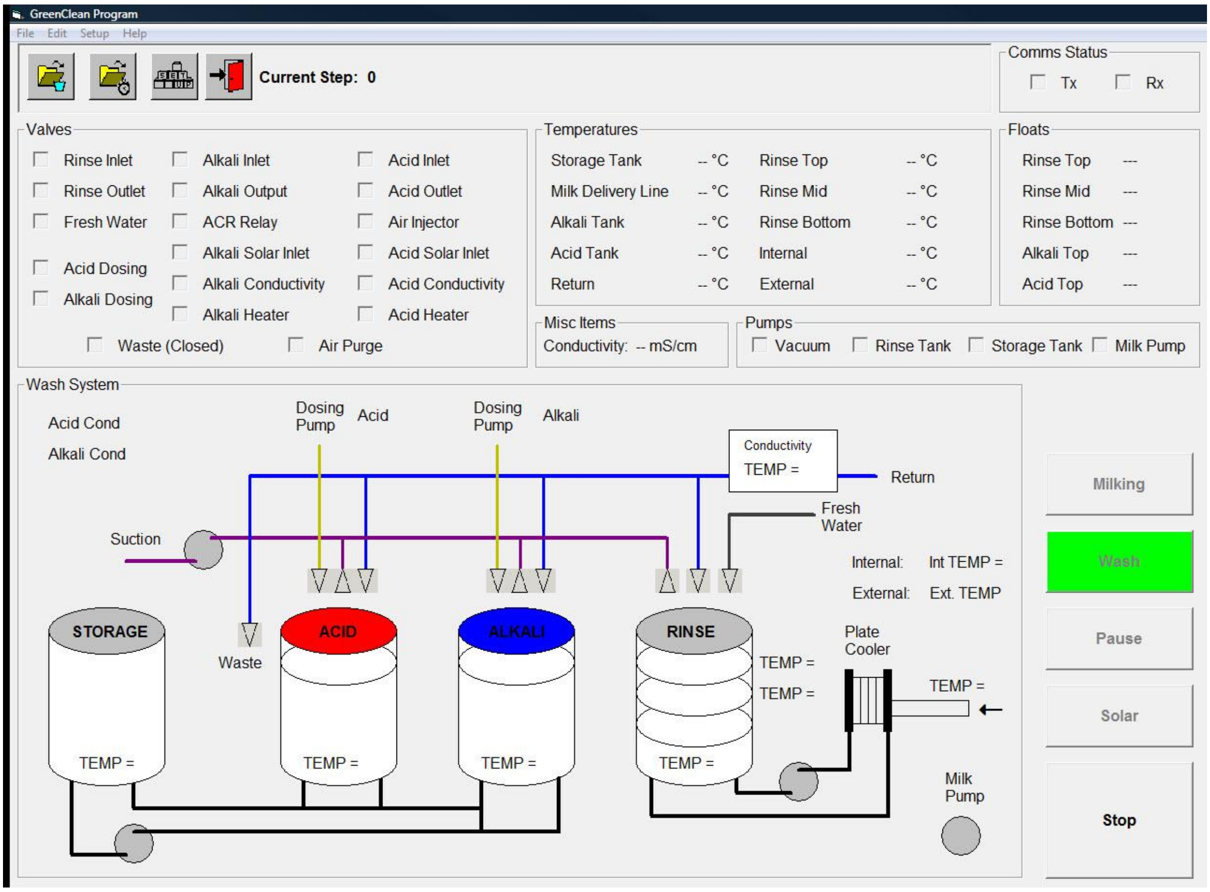
The Wash Tanks



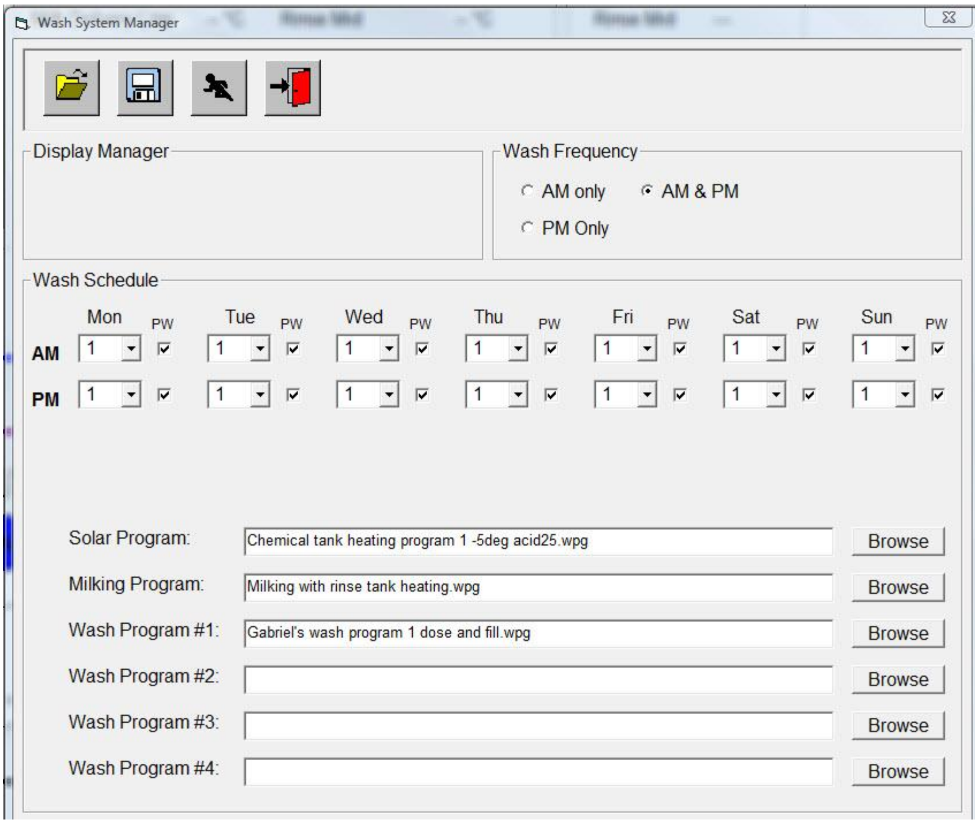
*Please note there are a couple of incorrect labels on this drawing (e.g. this is the chemical tank not the rinse tank).

The Software Program

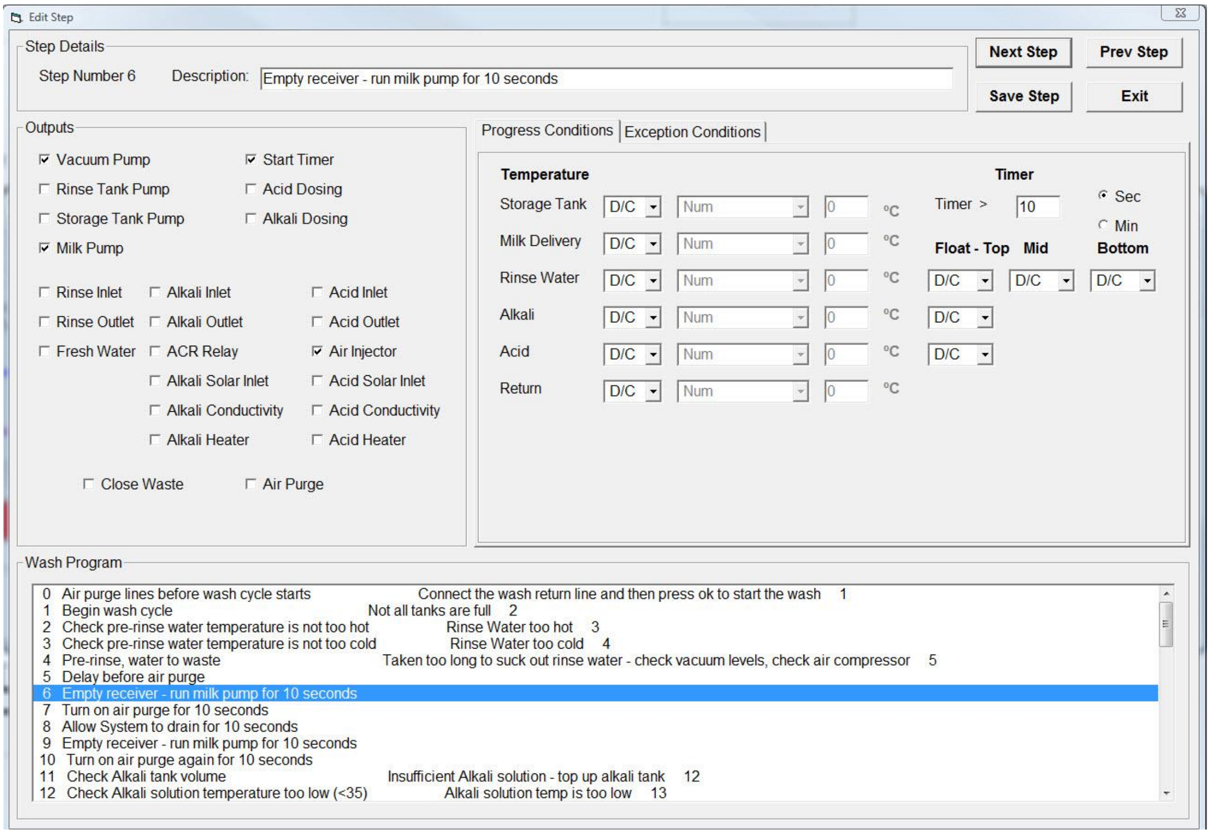
The user interface screen



The wash program scheduler



The wash program editor



Renewable Sources

To be investigated by the Industry Partners.

Configuration of milking machine components – thermal insulation

To be investigated by Industry Partners.

Proposed Cleaning Cycle

The CIP re-use system will use the following procedure

Table 11 - Re-use system cleaning cycle

Cycle 1	Cycle 2	Cycle 3	Cycle 4	Comments
Post-milking rinse. 30-35^{o}C, single pass.	Warm alkali wash. 50^{o}C (starting temp), recirculate for 3-5 mins.	Intermediate rinse at 30-35^{o}C, recirculate for 3 mins.	Warm/cold acid sanitiser recirculating rinse.	Reliant on potable water quality.

This program can be customised to suit the chemical requirements.

Valves, Senses & Switches

Floats & temperature sensors

Please refer to the appendix for details of the floats and temperature sensors used in the prototype.

Solar inlet valve

- 3-way ss ball valve with pneumatic actuator. It has a T-port configuration with a spring return. It operates on 12 V DC.

Tank inlet and outlet valves

- Keystone 2" butterfly valves with pneumatic actuator, operating on 12 V DC.

References

Griffiths, M. W. 1993. Applications of bioluminescence in the dairy industry. J Dairy Sci. 76:3118-3125.

Romney AJD (ed.). 1990. CIP: Cleaning in Place, 2nd edition. The Society of Dairy Technology, Cambridgeshire.

Vilar MJ, Rodríguez-Otero JL, Diéguez FJ, Sanjuán ML, Yus E. (2008) Application of ATP bioluminescence for evaluation of surface cleanliness of milking equipment. Int J Food Microbiol. May 2. [Epub ahead of print]

FINAL REPORT

Appendix

Program Specifications & Description

GREEN CLEANING

WASH SYSTEM

- PROGRAM DESCRIPTION

Title: Project Description.		**- CONFIDENTIAL -**
		© Copyright Creative Product Design 2008
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Preface

This document details various technical aspects of the AgVet GreenClean Wash System. It is intended for use by qualified engineering professionals for servicing and post-design engineering, therefore considerable knowledge of the various systems is assumed.

Abbreviations

ADC	Analogue to Digital Converter (MCU Module).
1WB	1-Wire Bus.
CPU	Central Processing Unit.
CPD	Creative Product Design.
I/O	Input and/or Output.
LCD	Liquid Crystal Display.
PC	Personal Computer.
PWM	Pulse Width Modulation.
WDT	Watchdog Timer (MCU Module).

Notes

Unless indicated otherwise, signals are active-High. Where a signal is labelled with /(signal name), that signal is to be considered active-Low.

'High' refers to a logical '1'.

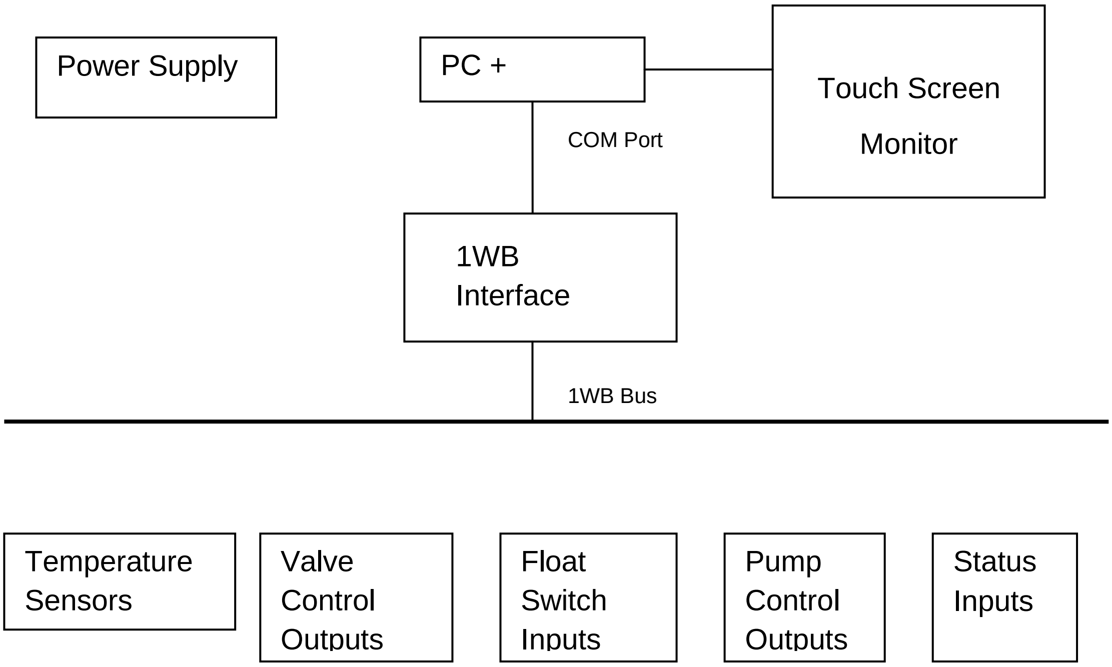
'Low' refers to a logical '0'.

Universal logic notation is used throughout this document. It describes the state of a signal as either 'asserted' or 'de-asserted' and is independent of whether that signal is active-High or active-Low. Hence an active-Low signal that is asserted is 'Low' or logical 0, whereas an active-High signal that is asserted is 'High' or logical 1.

Signal labels are shown in **Bold** throughout this document to differentiate from component or pin names.

Functional Description - Overview.

The inter-relationship of major functional blocks within the system are shown in the diagram below.



Descriptions below outline the purpose of each functional area and, where relevant, information important to correct functionality.

PC + Software.

An industrial PC running Windows XP was chosen as the platform for the Agvet Green Cleaning wash system. This solution provides the adaptability required during the development and trial stage and is not intended as a final commercial solution.

To allow the greatest flexibility during development the software includes a Manager, Editor and Interpreter, written in Visual Basic.

The Manager allows the selection and scheduling of different programs written with the editor. A maximum of two sessions per day ("AM" and "PM") are allowed with optional prewash (Milking Cycle) for each. One program can be selected for each of the Solar and

Milking cycles and up to four different wash programs can be specified and selected over the 7 day schedule..

The Editor enables specific functionality to be realised for each cycle, namely Milking, Washing and Solar and for this functionality to be altered as required. Each cycle consists of multiple steps that define the outputs that are enabled, and the conditions to progress to the next step, plus exception conditions for alternative progress. The conditions are made up of the various temperature and float switch inputs, plus timers.

The Interpreter decodes the program and provides the interface to and control of the pumps, valves, sensors and switch inputs. The current status of the system is displayed using a pictogram and tabulated data.

Other functions implemented include data logging of all inputs and automated dosing calculations based on the specific characteristics of the chemicals being used. Chemical characteristics can be altered to suit different chemicals as required.

Touch Screen.

The operator intereface is a 17” 1280X1024 touchscreen driven by the industrial PC under the control of Windows XP.

1WB Interface (EDS HA7E).

To further allow flexibility in the system setup, a One-wire bus (1WB) network of sensors was utilised. The 1WB is a proprietary network that can easily be expanded. A 1WB to RS232 convertor, the EDS HA7E, was selected to enable easy setup and configuration of the 1WB through the PC.

Temperature Sensor.

The temperature sensor is a 1WB device with digital output and CRC error checking.

Float Switch Input.

The float switch input is a 1WB digital I/O device. It has been interfaced with a reed switch and magnetic float to indicate fluid level.

Control Outputs.

The control outputs consist of a 1WB digital I/O device connected to a relay to provide both NO and NC dry contacts.

Analogue Input.

The analogue input is made up of a 1WB interfaced Analogue to Digital Converter with 4-20mA loop inputs. The loop inputs are connected to a Jumo CTI-500 Conductivity and Temperature sensor, which takes readings from the return water.

Power Supply.

The Power supply consists of a wide-input switch mode power supply to allow operation over a wide and potentially varying input voltage, plus battery backup for brown and black-out power failures.

System Name Cross-Reference.

Valve Number/Name

V1	Rinse Outlet
V2	Alkali Outlet
V3	Acid Outlet
V4	Waste Outlet (Normally Open)
V5	Rinse Inlet
V6	Alkali Inlet
V7	Acid Inlet
V8	Rinse Fresh Water Inlet
V9	Alkali Fresh Water Inlet
V10	Acid Fresh Water Inlet
V11	Alkali Solar Bypass
V12	Alkali Solar Inlet
V13	Acid Solar Bypass
V14	Acid Solar Inlet
V15	Air Purge
V16	Acid Heater
V17	Alkali Heater

Float Number/Name

F1	Rinse Top Float
F2	Rinse Mid Float
F3	Rinse Bottom Float
F4	Alkali Top Float
F5	Acid Top Float

Temperature Number/Name

T1	Storage Tank
T2	Pre-Vat Milk
T3	Rinse Tank
T4	Alkali Tank
T5	Acid Tank
T6	Return

Pump Number/Name

P1	Vat Pre-cooler
P2	Storage Tank
P3	Acid Outlet
V4	Waste Outlet (Normally Open)
V5	Rinse Inlet

Suitability checklist for a Green Cleaning trial site

Below is a checklist to help assess the suitability of a farm as a trial site for a "Green Cleaning" system.

Farm Details		
Contact Person		
Farm Address		
Contact phone numbers	Home :	Mobile :
Milk company supplied		
Milking machine brand		
Dealer who services milking machines	Contact name & address :	Contact phone number :

Water	The requirement is to use high quality water for all cycles of the wash. Similarly, high quality water is preferred for use in the thermal storage tank which circulates through the heating coils inside the chemical tanks. Rain water/town water or similar quality with hardness <150 ppm ($CaCO_3$) & iron level < 0.5 ppm. A clean closed tank that collects rain water is preferred. Quantity requirements: initial setup ~ 1800 l, then ~600-800 l/day.	Yes	No
	Are there sufficient volumes of water available throughout the entire milking season?	☐	☐
	Is there suitable quality of water available throughout the entire milking season?	☐	☐

Floor Space	A “Green Cleaning” system requires three tanks (600 l capacity). Each tank occupies ~1m^2. The specific design of the system to be installed will dictate the actual space requirement. Consideration must be given to the storage requirements of the chemicals. An area of 3.5 x 1.5 m is the suggested minimum space requirement.	Yes	No
	Is there sufficient “floor space” to accommodate the new cleaning system?	☐	☐

Milking Machines	*The milking machines should meet the minimum requirements for milking machine performance as determined by the AMMTA milking machine test procedure. A regular maintenance program should be in-place with scheduled replacement of milk contact rubberware*	Yes	No
	Do the milking machines satisfy **ALL** the minimum requirements for milking machine performance as determined by the AMMTA milking machine test procedure?	☐	☐
	Do the milking machines have a scheduled maintenance program?	☐	☐
	Is the milk contact rubberware is replaced as per manufacturer’s recommendations?	☐	☐
	Do the milking machines drain completely?	☐	☐

Renewable Energy Sources	*The most likely forms of renewable energy will be solar or heat reclaim. Whilst products such as heat pumps can be used, they are grid connected and the energy supply is from non-renewable sources. Likewise, adaptation of existing HWS could also be considered but again, their energy source is typically non-renewable.*	**Yes**	**No**
Solar Hot Water Systems Solar hot water systems are better suited to some geographical areas than others. Having access to an unobstructed north-facing roof for the solar collectors is paramount. Consultation with a solar hot water specialist to determine size & performance characteristics is necessary.			
	Is the orientation for solar hot water service correct?	☐	☐
	Is there sufficient "floor space" to accommodate the water storage tank(s)?	☐	☐
Heat Reclaim Systems If a heat reclaim system on the milk tank refrigeration unit is a considered possibility/option then a farm with a minimum daily production of ~7,000 l is preferred. On smaller farms a year-round or split calving farm is best suited to achieving the minimum daily production volumes. It is important to note that many factors are considered when calculating the minimum milk production requirements. Such factors include: • Type & performance of the pre-cooling system; • Type of refrigeration system (different refrigerant gases have different evaporative temperatures); • Type and performance of the heat reclaim system. • Volume of chemical wash solutions to be heated. • Temperatures to which each chemical wash solution must be heated. • How the rinse water will be heated.			
	Is there sufficient "floor space" to accommodate the heat reclaim system?	☐	☐
	Is the heat reclaim system close enough to the chemical wash tanks to minimise heat losses?	☐	☐
	Can the heat reclaim system and the chemical wash system be connected without pipework causing obstructions?	☐	☐

Milk Quality	*The farm should be able to demonstrate a record of good (premium) milk quality. The quality parameters should include BMCCs, Temperature, TPC/Bactoscan & thermodurics.*	**Yes**	**No**
	Are all parameters for good milk quality met?	☐	☐
	Are the results consistently good throughout the year?	☐	☐

OH & S	*The farm will be a workplace & demonstration site and so a safe environment should exist at all times. A risk assessment should be undertaken and any identified risks mitigated.*	**Yes**	**No**
	Does the site provide a safe workplace?	☐	☐
	Is the site safe?	☐	☐
	Have identified risks been mitigated?	☐	☐

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