Chlorine-free cleaning of milking equipment to avoid residues and achieve low bacterial counts in bulk tank milk

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What are the topics that will be covered?

- Chlorine-free cleaning what changes are required
- Powder vs Liquid products
- Frequency of hot washes on the cost of cleaning
- Milking equipment cleaning protocols
- Commercial farm study; main observations

Overview of Chlorine free cleaning

- Chlorine was very effective product against protein deposits, thermoduric bacteria and was also effective if used with cold water

- The republic of Ireland is one of the first countries to adopt new chlorine-free cleaning of milking equipment

- Robotic systems use chlorine-free protocols
  - high temperatures and higher concentrations of caustic

- Removal of chlorine is compensated by key changes to existing wash protocols- individual or combinations of changes

  - » It is <u>NOT</u> just a case of changing drums

What are the main products used for cleaning milking equipment?

- **Detergent: sodium hydroxide/caustic, surfactants, sodium carbonate**
  - **Organic residue removal;**
    - » Lipids (fats), proteins and carbohydrates (sugars) that originate from milk

- **Acid: phosphoric/nitric**
  - **Mineral deposit removal;**
    - » Calcium, magnesium, iron and other minerals that originate in water and to a lesser extent milk

- **Peracetic acid: acetic acid, hydrogen peroxide, peracetic acid**
  - **Sanitizer -** the only alternative disinfectant to chlorine

What is required for effective chlorine free cleaning?

- Higher detergent usage rates;
  - 0.7% hot water (previously 0.5%)
  - 1% cold water

- Hot water;
  - » Hot wash start temperature of 75/80°C
  - » Hot wash finish temperature ideally >45/50°C
  - » 7 hot washes minimum with liquid products

- Increased use of 'existing' acid based products phosphoric/ nitric;
  - » 2 descale washes per week Or use new 'ONE for ALL' acid based products

- Peracetic acid; Used in an additional final rinse -optional depends on the wash protocol chosen

These steps compensate for the removal of chlorine from the routine!

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Chlorine free cleaning –caustic products

- Liquid caustic products (sodium hydroxide) have much lower caustic content (20%) than powder products (80%)
- Recycling of liquid products no longer recommended
- Higher detergent usage rates are required when using cold water; up to 50% more required (always the case)
  - Example 100 litres water (detergent; 0.5% = hot 500 mls: 1% cold = 1 litre)
- Caustic concentrations/ viscosity higher in new CF detergent products as compared to detergent/sterilizer products

It is critical to re-calibrate equipment

Chemical analysis of a sample of detergent products collected at farm visits

Liquid products	
Product	% NaOH
Altradet CF	20.39
ArkAline	20.7
Avalaksan	23.18
BFS extreme clean	27.59
CIPSAN	27.75
Coolclean	23.45
Cryosan CF	29.73
Diversey Cip cleaner	22.95
HYPRAL ONE	30.23
Nadal	18.2
Parlosan	25.85
Turbosan CF	27.32

Powder products		
	% NaOH	% Na_2CO_3
	Sodium Hydroxide	Sodium Carbonate
Asepto	68.11	12.16
KoldKleen	70.12	15.32
Altradet	64.78	22.6
Supercleen	69.42	15.36
RX5000 DELAVAL	49.91	30.49
Universan	56.96	30.58
Clearway	49.43	19.36
Purechem	74.28	16.92

Impact of the percentage of sodium hydroxide present in a detergent product in conjunction with the usage rate on the concentration of the working solution (ppm)

Usage rate	Sodium Hydroxide concentration				
	18%	20%	24%	28%	75% (powder)
0.5% (225ml/45L)	900	1000	1200	1400	3750
0.6% (270ml/45L)	1080	1200	1440	1680	
0.7% (315ml/45L)	1260	1400	1680	1960	
0.8% (360ml/45L)	1440	1600	1920	2240	
1% (450ml/45L)	1800	2000	2400	2800	

- **Target: working solution**
- **> 1200 ppm with hot water**
- **> 2000 ppm with cold water**

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Chlorine-free cleaning-Hot water usage

- Adequate hot water is vital: 9 - 12 litres/unit
- 7 hot washes per week-minimum with liquid products
  - » Less hot washes (n=3) necessary when using powder
- Water temperature- check in the wash trough
  - » Start of cycle: 75/80^{o}C
  - » End of cycle: 45/55^{o}C

Maintaining the HOT detergent wash cycle temperature

- Plate cooler water could be used for the post milking rinse
- Warm post-milking rinse: 20 - 30^{o}C
- Option to send the first 10 - 20 litres of hot water to dump
- Circulation times for detergent cycle too long; 8 - 10 min sufficient
- Fast fill
- Insulated trough/lid

Drainage of post milking rinse vital

Impact of the frequency of hot washes and heating method on the weekly cost of cleaning a 20 unit milking machine

Hot washes	Heating method	Detergent Usage rate	Detergent cost Per week	Peracetic acid cost per week	Heat cost Per week	Total Cost
14	Electrical (7 NR/7DR)	200 l x 14 x 0.6%	43.43	0	29.26 + 58.52	131
14	Gas	200 l x 14 x 0.6%	43.43	0	32.76	76
14	Oil	200 l x 14 x 0.6%	43.43	0	34.16	78
7	Electrical (7NR)	200 l x 7 x 0.6% 200 l x 7 x 1%	21.74 + 36.19	42.56	29.26	130
2	Electrical (2NR)	200 l x 2 x 0.6% 200 l x 12 x 1%	6.20 + 62.04	42.56	8.36	119

20 units, 10 litres of water per unit, 14 caustic washes, Detergent cost €517/200L (2.59/L), 1.2 L (0.6%);2.0 L (1%). Peracetic acid cost 3.63/L (14 Litres/unit, usage 0.15%).
John Upton water heating costings: Gas € 1.17, NR € 2.09, DR € 4.18, Oil € 1.22, per 100 litres

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Chlorine-free cleaning-Use of Acid products

- 2 to 12 acid washes per week –depends on the protocol (e.g. 2 acid washes if 14 hot or 3 acid if 7 hot washes)
- Descale acid products-contain phosphoric/nitric acid-same as used for traditional wash protocols
- 'ONE for ALL' acid based products – descale/clean/disinfect-more likely used for bulk tank cleaning
- Water hardness critical
  - water softener or more acid washes

Peracetic acid the alternative to chlorine

- Peracetic acid breaks down to safe and environmentally friendly residues
- Can be used for the disinfection of clusters between individual cows
- Can be used in the final rinse water
  - Particularly where there is an issue with the microbial quality of the water supply
- **Further rinsing with water to remove stains is not considered necessary – complete one hour before milking!**
- Peracetic acid very effective against thermoduric bacteria
- Low usage rates e.g. 60mls per 45litres

- *Chlorine-free cleaning Protocols:*
  - » *5 chlorine-free milking equipment cleaning protocols*
  - » *& 5 chlorine-free bulk tank cleaning protocols*

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OPTION 1: Chlorine free cleaning based on powder detergent (sodium hydroxide) and peracetic acid in an additional rinse

***Ideal for manual systems**

After each AM milking

1. Wash outside of clusters and jetters. Attach jetters to clusters
2. Remove or replace the milk filter sock
3. Rinse plant with 14 litres (3 gals) of warm or cold water per unit
4. Add an approved *powder detergent **(sodium hydroxide)** at the recommended use rate **in cold water or hot water at 70-80°C (minimum 3 hot washes per week)**, allowing about 9 litres (2 gals) of solution per unit
   - Circulate the wash solution for 8-10 min, having allowed the first 5 litres to run to waste. Can retain for the PM wash occasion.
5. Rinse the plant with a minimum of 14 litres (3 gals) of water per unit immediately after the wash cycle or prior to the next milking
6. Add peracetic acid at recommended rates in an additional cold water rinse

After each PM milking

1. Wash outside of clusters and jetters. Attach jetters to clusters
2. Remove or replace the milk filter sock
3. Rinse plant with 14 litres (3 gals) of warm or cold water per unit
4. Re-use the detergent wash solution retained from AM milking.
   - Circulate the solution for 8-10 min
5. Rinse the plant with a minimum of 14 litres (3 gals) of water per unit
6. Add peracetic acid at recommended rates to an additional cold water rinse

Replace the *powder detergent with an **acid** product on at least one occasion per week and more regularly if peracetic acid is not used twice daily

OPTION 2: Chlorine-free cleaning based on liquid detergent (AM) and an Acid (PM) (Sodium hydroxide/phosphoric acid)

***Ideal if hard water is an issue**

After each AM milking

1. Wash jetters and outside of clusters and remove or replace the milk filter
2. Rinse the plant with 14litres (3 gals) of warm or cold water per unit
3. Add an approved **liquid detergent** (sodium hydroxide) at the recommended rate in hot water 75 - 80°C , allowing about 9 litres (2 gals) of solution per unit
   - *Circulate the wash solution for 8-10min,having allowed the first 5 litres to run to waste*
4. Rinse the plant with a minimum of 14 litres (3 gals) of water per unit immediately after the wash cycle

After each PM milking

1. Wash jetters and outside of clusters and remove or replace the milk filter
2. Rinse the plant with 14litres (3 gals) of warm or cold water per unit
3. Add an approved **Acid cleaning product (phosphoric acid/ all in one products)** at the recommended rate in cold or hot water 75 - 80°C allowing about 9 litres (2 gals) of solution per unit
   - *Circulate the wash solution for 8-10 min,having allowed the first 5 litres to run to waste*
4. Rinse the plant with a minimum of 14 litres (3 gals) of water per unit immediately after the wash cycle

OPTION 3: Chlorine free cleaning based on liquid detergent (sodium hydroxide) and an acid (phosphoric/nitric)

***Ideal for Auto systems & larger sized plants**

After each AM milking

1. Wash outside of clusters and jetters. Attach jetters to clusters
2. Remove or replace the milk filter sock
3. Rinse plant with 14 litres (3 gals) of warm or cold water per unit
4. Add an approved liquid detergent (sodium hydroxide) **on 4 occasions per week** and an acid product on **3 separate occasions per week** (Monday, Wednesday, Friday) at the recommended use rate **in hot water** at 75 - 80°C allowing about 9 litres (2 gals) of solution per unit
   - Circulate the solution for 8-10 min, having allowed the first 5 litres to run to waste
5. Rinse the plant with a minimum of 14 litres (3 gals) of water per unit immediately after the wash cycle

After each PM milking

1. Wash outside of clusters and jetters. Attach jetters to clusters
2. Remove or replace the milk filter sock
3. Rinse plant with 14 litres (3 gals) of warm or cold water per unit
4. Add an approved liquid detergent (sodium hydroxide) at the recommended use rate **in cold water**, allowing about 9 litres (2 gals) of solution per unit
   - Circulate the solution for 8-10 min having allowed the first 5 litres to run to waste
5. Rinse the plant with a minimum of 14 litres (3 gals) of water per unit immediately after the wash cycle

Include peracetic acid in an additional cold water rinse **twice daily.**

OPTION 4: Chlorine free cleaning based on liquid detergent (sodium hydroxide) used with hot water twice daily

***Necessary for larger plants with milk meters/dump lines**

After each AM milking

1. Wash outside of clusters and jetters. Attach jetters to clusters
2. Remove or replace the milk filter sock
3. Rinse plant with 14 litres (3 gals) of warm or cold water per unit
4. Add an approved *liquid detergent (sodium hydroxide) at the recommended use rate **in hot water** at 75 - 80°C allowing about 9 litres (2 gals) of solution per unit
   - Circulate the wash solution for 8-10 min, having allowed the first 5 litres to run to waste
5. Rinse the plant with a minimum of 14 litres (3 gals) of water per unit immediately after the wash cycle

After each PM milking

1. Wash outside of clusters and jetters. Attach jetters to clusters
2. Remove or replace the milk filter sock
3. Rinse plant with 14 litres (3 gals) of warm or cold water per unit
4. Add an approved liquid detergent at the recommended use rate **in hot water** at 75 - 80°C allowing about 9 litres (2 gals) of solution per unit
   - Circulate the wash solution for 8-10 min, having allowed the first 5 litres to run to waste
5. Rinse the plant with a minimum of 14 litres (3 gals) of water per unit immediately after the wash cycle

*Replace the liquid detergent with an **acid** product on at least two occasions per week

Milking machine CF cleaning routines used by the 13 nominees of the NDC/Kerrygold milk quality awards competition-2022

Farm No	Hot washes	Temp	Man/Auto	Descale	Peracetic acid	Liquid or powder	Product Name	TBC
1	7	90	M	2	Y	L/P	DeLaval	9
2	14	70	A	1	N	L	Kilmore CF	7
3	7	75	M	1	Y	P	Circodine CF	7
4	7	75	M	1	Y	P	Circodine CF	7
5	7	75	A	2	Y	L	Autosan Blue	5
6	4	70	M	3	N	P	Dairygold cold cleaner	8
7	7	70	M	1	Y	P	Asepto Powder	4
8	1	75	M	1	N	P	Deosan Powder	4
9	4	85	M	1	N	P	Asepto Powder	5
10	2	85	M	1	N	P	Deosan Powder	7
11	7	80	M	1	Y	L	Turbosan CF	4
12	7	80	M	3	Y	P	Circodine CF	12
13	14	75	A	7	N	L	Turbosan CF	3

10 used manual wash; Powder product = 9; Avr. water temp 77°C; Avr. Hot washes = 7; Peracetic acid = 7

Range of products used for cleaning the milking machine

Average Thermoduric count 133 cfu/ml

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Chlorine-free cleaning of bulk milk tanks

- **Positive:** Chlorine-free bulk tank cleaning – generally not a problem!
  - All stainless steel
  - Always hot water

- Critical to re-calibrate auto washer and bulk tank washer if changing to higher caustic product (chlorine-free)-caustic content can be higher - (example 2%↑29%)

- **Negative** : detergent suck up tubes more likely to get blocked over time

Cleaning protocols that can be used for a Bulk Milk Tank

I. Caustic detergent and acid descaler (phosphoric/nitric) used on alternate days.

II. Caustic detergent maybe used after two milk collections and an acid detergent used after every third collection.

III. Caustic detergent could be used after each collection followed by a rinse and then peracetic acid added to an additional final rinse.

IV. 'One for all product' used after each collection.

V. 'One for all product' used after three collections and a caustic product used at the fourth collection.

New Study:

Investigating the Farm Management Factors that Influence the Performance of Chlorine Free Cleaning Protocols on Commercial Dairy Farms.

Objective of Study

- To establish what management practices have the most influence on the success of CF cleaning routines as measured by milk total bacterial counts
  - » **Comparing extremes;**
    - **"High TBC" dataset (≥25,000 cfu/ml)**
    - **"Low TBC" dataset (≤15,000 cfu/ml)**

Secondary objectives;

1) Study management factors and their impact on milk thermoduric counts

2) Evaluate residue levels in farm milk and water;

Farm Study – How did it work?

- **11 participating co-ops;** Arrabawn, Aurivo, Barryroe, Centenary Thurles, Dairygold, Drinagh, Kerry Agribusiness, Lisavaird, North Cork Creameries, Tipperary & Tirlan

- **105 farms** were visited during July, August, September & October; 5 – 15 farms from each co-op were visited

- **Farmer interviewed** on their overall milk quality management

- **Key measurements were taken;**
  - Water volumes for both rinse and wash cycles
  - Hot wash starting temperatures
  - Detergent volumes used for hot/cold washing

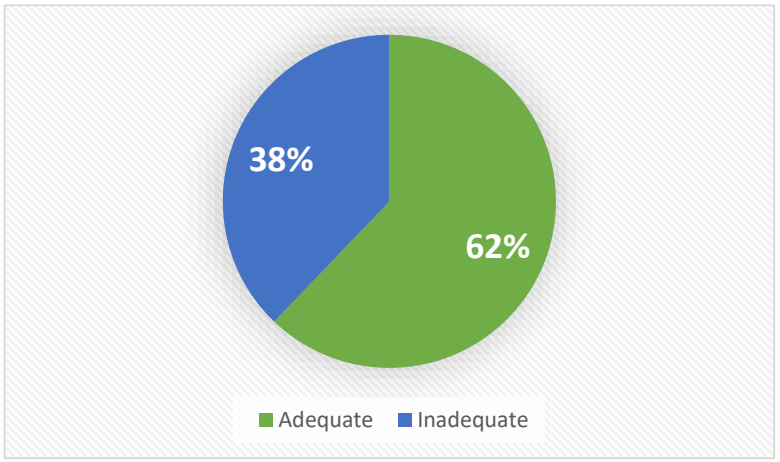
- **Environmental and equipment cleanliness assessed;**
  - Dairy, parlour, clusters, claw pieces & collecting yard assessed for cleanliness
  - Rubberware assessed for porosity and damage
- **Samples taken of;** Milk – chlorate/ TCM analysis; Water – chlorate/ chlorine/ hardness analysis

What were the main observations regarding the cleaning process?

- Basic flaws are present on farms such as deficiencies in;
  - Detergent usage rates; Hot wash starting temperature; Hot wash frequency

- Same volumes of detergent used for both hot and cold **– 97% of farmers using liquid caustic were using the same amount of detergent for hot and cold.**

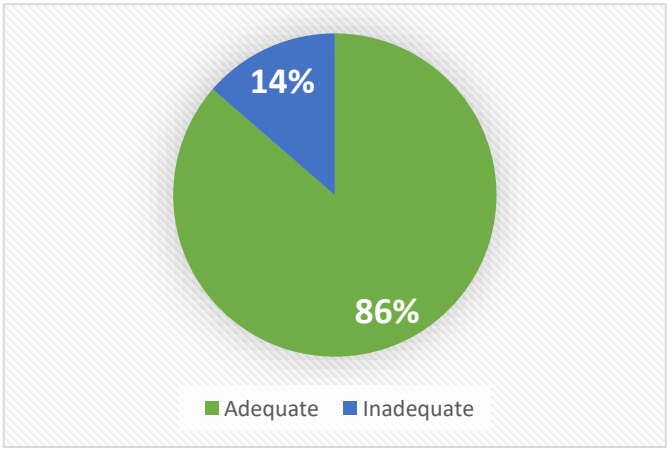
Detergent usage rates-Hot wash



38% of farmers using liquid caustic were not using the required amount of detergent

(based on the manufacturers recommended usage rates (0.5%) with hot water).

Volume of detergent solution per unit

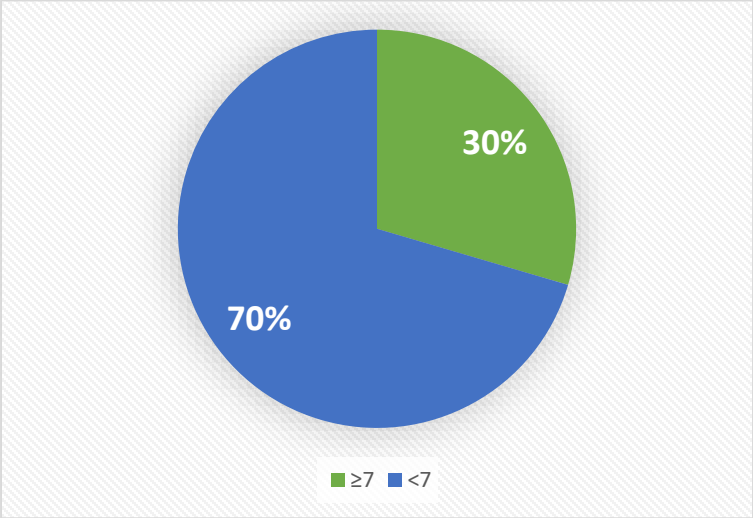


14% of farms had insufficient water volume for washing.

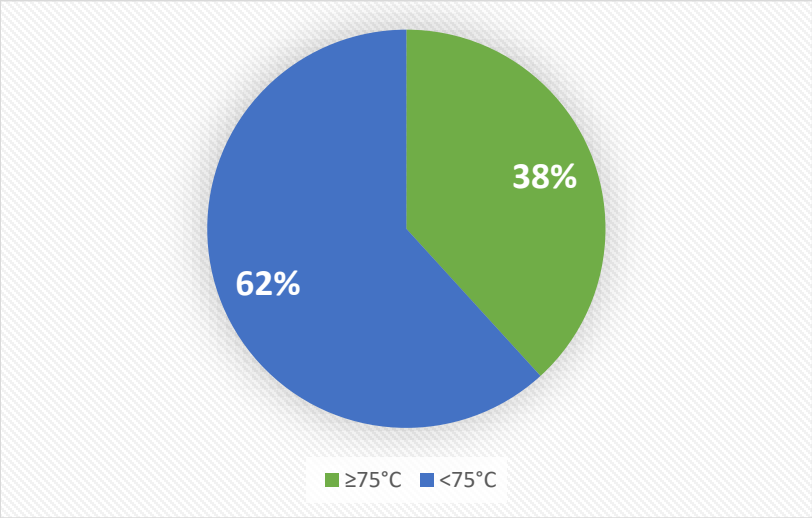
Adequate volume is deemed to be 7 litres/unit plus (9 litres recommended).

Frequency and starting temperature of hot washes

Frequency of hot washing



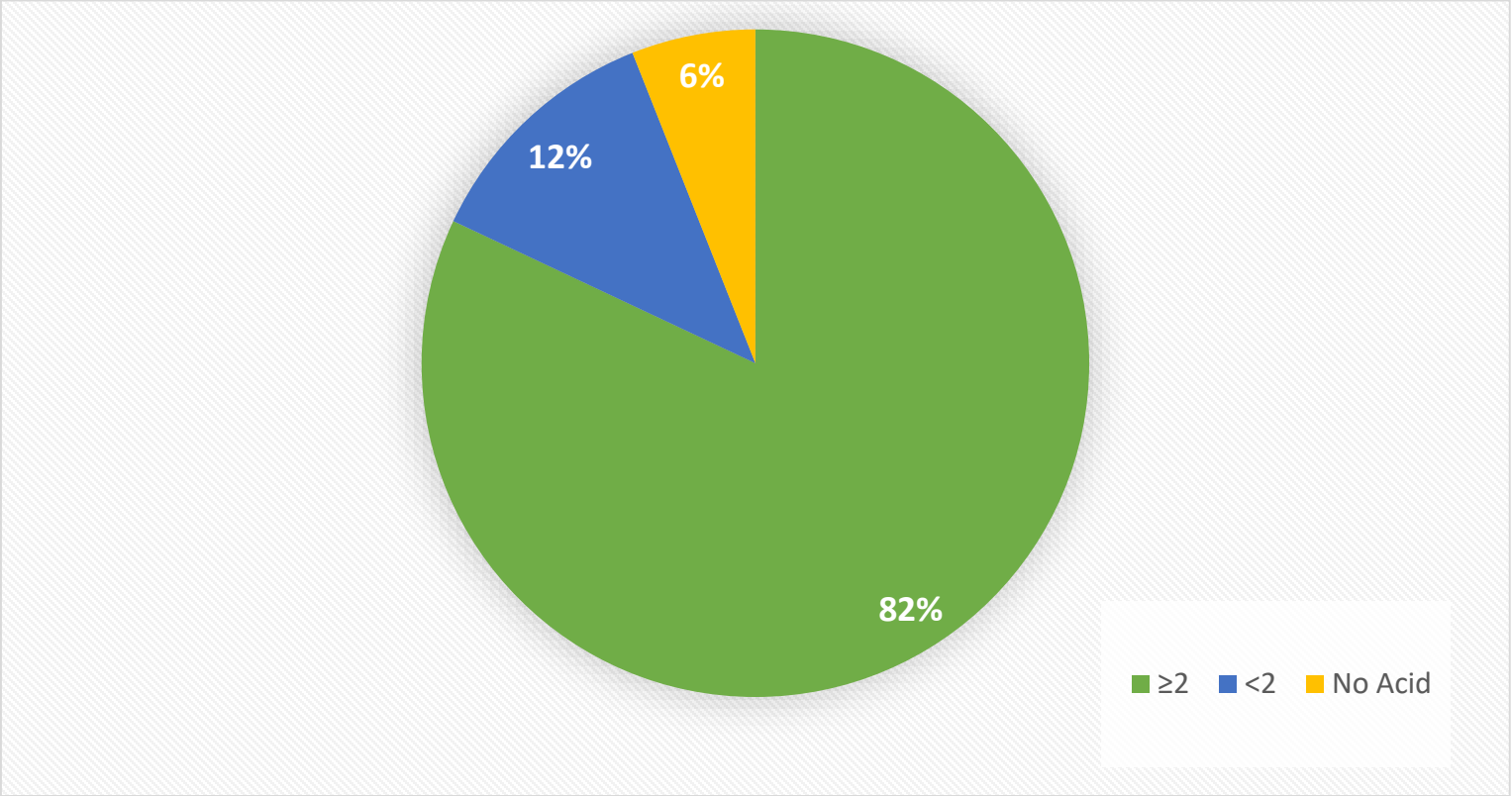
Starting temperature of the hot wash



The majority (70%) of farmers using < 7 hot detergent washes per week (liquid detergent)

Starting temperatures for hot washes were < 75 ^{0}C on 62% of farms (liquid detergent)

Frequency of acid washing for milking machines



- 18% of farms conducting < 2 acid washes per week.
- **6% used no acid**

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Summary of main faults (liquid products)

- 97% not using sufficient detergent for cold wash
- 38% not using sufficient detergent for the hot wash (0.5%)
- 70% not using enough hot washes
- 62% of hot washes with low temperature
- 18% not using sufficient number of acid washes
- 6% have no acid wash
- 14% not using a sufficient volume of water for main wash cycle

Further observations about the wash routine;

- Some farms using higher rates of products, which indirectly is compensating for lack off or poor hot washes
- Running out of detergent and not replacing it immediately – particularly in automatic systems!
- Using out of date detergents/ acids
- Not using detergent after evening milking; JUST RINSING!
- Recycling liquid detergent – caustic % too low to allow recycling
- Wash trough too small -Low water levels for main wash cycle (5 litres)
- Circulating detergent for too long; 15 to 20 min
- Wrong tubes in detergent/acid drums

Further observations about the wash routine

- No hot water used
- Wash water start temperature as low as 35 ^{o}C for liquid products – temperature in trough always lower than farmers estimate
- Poor drainage after wash cycles impacted on hot wash temperature and residues
- Hard water issue; stain on trough surfaces; easy test
- No filter sock present for the wash cycle where plate cooler present
- Reusing filter sock for multiple occasions
- Vacuum Airline never cleaned
- Dump lines not regularly washed

Main cleaning issues observed in automatic systems

- All farms had some deficiency in either the cleaning or cooling programmes
- Automatic draining not present in many plants influencing hot wash cycle circulation temperature & potential residues
- No farm with auto wash using first dump option
- Auto-washers not recalibrated for chlorine-free products
- Rate of detergent usage lower than required in most cases and same usage settings used for hot and cold circulation

Put the correct tube in the correct drum!

RED = ACID

BLUE = DETERGENT

What were the consequences of these deficiencies?

- Constantly elevated or volatile TBC counts
- Constantly elevated or volatile thermoduric counts
- Physically dirty milking equipment

Deposits in the claw bowl- first place to check

Organic (milk) deposits

Inorganic (mineral) deposits

Farm trial-58% clean; 20 % slight deposits; 22% large deposits

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Main observations on bulk milk tank cleaning

- Tank cooling time taking up to 4 hours to achieve required temperature
- ESB supply issue; compressors turned off during milking
- Plate coolers disconnected or with restricted water supply
- Wrong tubes in detergent/acid drums
- Two caustic products on bulk tank with no acid
- No caustic product used on bulk tank just an acid (not 3:1)

What can I do to make sure of a good wash routine?

- Measure the trough to calculate the water volume used for detergent cleaning
- Read the recommendations on the product drum
- Establish the usage rate required and calibrate for each individual wash type: Hot detergent, cold detergent, acid, Peracetic acid
- Check that tubes match the product
    - RED = Acid Blue = Detergent
- Check for auto drainage of plant between wash cycles
- If present in the Auto-washer-activate the first dump option

Choose a wash routine suitable for the plant

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Example of calculation on how much detergent should be used

- **16 unit plant (target 9 to 12 litres a unit for detergent wash)**
- **Trough measurement: at water level mark**
  - Multiply the width x height x length = cubic meters (1 cubic meter = 1,000 litres)
  - Example- 37 Height, 42 Width, 113 length = 175,603
- **Divide 175,603 by 1000 = 175 litres of water in trough**
  - (175/16 = 10.9 litres per unit)
- **Detergent recommended concentration with hot water = 0.7%**
- **Multiply 175 litres by 0.7 % and divide by 100= 1.23 litres of detergent required**
- **1% concentration if using cold water = 1.75 litres**

Milk residue results - farm study

Chlorate & perchlorate

- 96 milk samples were tested at Ashtown for Chlorate and Perchlorate;
  - 6 of these samples had detectable levels of chlorate; 0.0023 – 0.013 mg/kg.
  - 6% detection rate - slightly lower than the bulk milk study (8% detection rate) that was conducted in 2020 & 2021.
- 3 of the 96 farms displayed detectable levels of perchlorate; 0.0023, 0.0025 & 0.0025 mg/kg (just above the LOD); 3% detection rate.
- Only 1 of the 3 farms had both chlorate and perchlorate detected in milk

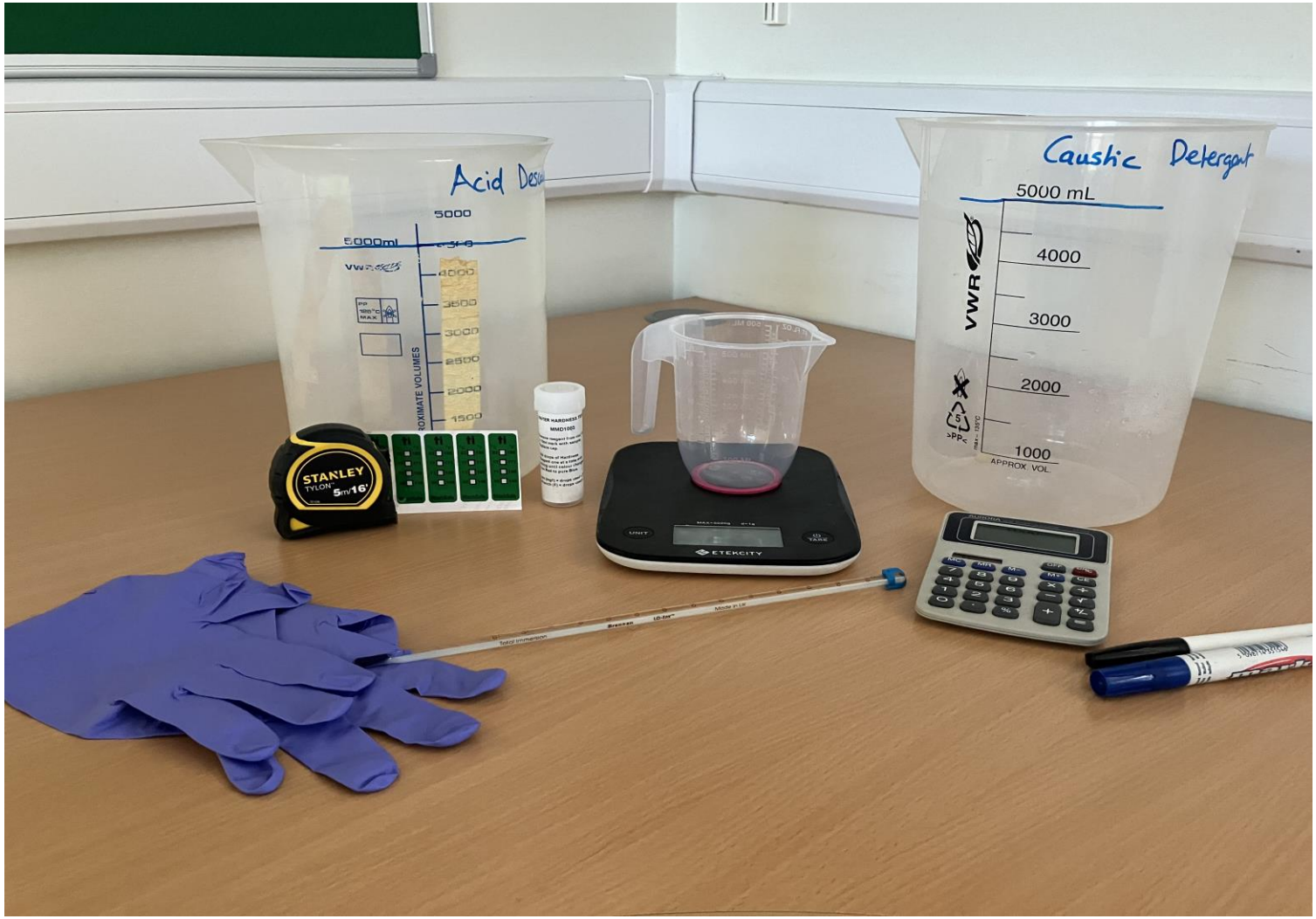
TCM

- 100 samples tested for TCM at Moorepark
  - 7% of these samples had Levels > 0.00124 mg/kg in line with the bulk milk study with 6% of samples detected in 2022

Observations from farms that failed TCM and had detected chlorate levels

	Farm observations--TCM fail
26	No label on detergent, poor water supply
31	386 ppb highest water chlorate reading
32	?
38	Detergent/ steriliser used
40	previous chlorate fail
62	Product no label, recycling detergent, chlorate detected
83	Recycling detergent, pre-spray no wipe, chlorate detected
	Farm observations - Detected chlorate
35	Recycling detergent, detected TCM, water getting into milk
37	Detergent steriliser used, also perchlorate detected
97	Recycling detergent , TCM detected, milk vol low, group/well
106	Admitted using chlorine intermittingly
	Farm observations - Detected perchlorate
43	Only common observation was that all 3 farms used silicon rubber, BUT 30 other farms used silicon
58	

Troubleshooting Tool Kit



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Temperature strips for stainless steel wash trough

Temperature Indicators Ltd, Manchester, United Kingdom.

Conclusions

- **Previously the use of chlorine masked a lot of poor cleaning practises on farms in particular the limited use of hot water**

- **Unless these management issues are addressed it will limit the success of chlorine-free cleaning at farm level**


Thank you