The Big Four
SPC, LPC, PI, & Coliform
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GEA Farm Technologies

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Food Science
The “BIG 4”

—Milk quality reports

• *Bacteria counts*

• *Lab Pasteurized Counts*

• *Coliform Counts*

• *PI Counts (Preliminary Incubation)*
You have got the information – now what?
Who levels?

- **SPC (Standard Plate Count)**
  - Less than 5,000
  - >10,000 = action is needed

- **PI (Preliminary Incubation Count)**
  - Less than 10,000
  - > 25,000 = action is needed

- **LPC (Lab Pasteurized Count)**
  - Excellent = less than 100
  - >200 = action is needed

- **E-coil (Coliform Counts)**
  - Excellent = less than 50
  - >200 = action is needed
What do you think about these counts?

<table>
<thead>
<tr>
<th></th>
<th>Coi</th>
<th>LPC</th>
<th>PLC</th>
<th>100%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10</td>
<td>10</td>
<td>3</td>
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</tr>
<tr>
<td>3</td>
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<td>3</td>
<td>10</td>
<td>50</td>
<td>2</td>
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<td>2</td>
<td>10</td>
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<tr>
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<td>1</td>
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<tr>
<td>1</td>
<td>10</td>
<td>10</td>
<td>1</td>
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</table>
What about these counts?

<table>
<thead>
<tr>
<th>Coli</th>
<th>LPC</th>
<th>PPLC</th>
<th>CPC</th>
<th>PPC</th>
<th>PLC</th>
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<tbody>
<tr>
<td>89%</td>
<td>17</td>
<td>4</td>
<td></td>
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<tr>
<td>90</td>
<td>50</td>
<td>24</td>
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<tr>
<td>50</td>
<td>10</td>
<td>28</td>
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<td>370</td>
<td>220</td>
<td>34</td>
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<td>70</td>
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<td>5</td>
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<tr>
<td>170</td>
<td>620</td>
<td>6</td>
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<td>40</td>
<td>10</td>
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<td>6</td>
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<tr>
<td>170</td>
<td>20</td>
<td>5</td>
<td></td>
<td></td>
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<td>10</td>
<td>9</td>
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<td>10</td>
<td>10</td>
<td>4</td>
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</table>
# Milk Quality Tests

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Name of Test</th>
<th>High</th>
<th>Acceptable</th>
<th>Excellent</th>
<th>Dirty Equipment</th>
<th>Infected Udders</th>
<th>Environment</th>
<th>Improper Cooling</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPC</td>
<td>Standard Plate Count</td>
<td>&gt;10,000</td>
<td>1,000-10,000</td>
<td>&lt;1,000</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>IPC</td>
<td>Lab Pasteurized Count</td>
<td>&gt;100</td>
<td>10-100</td>
<td>&lt;10</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>PI</td>
<td>Preliminary Incubation</td>
<td>&gt;15,000</td>
<td>5,000-15,000</td>
<td>&lt;5,000</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Acidity</td>
<td></td>
<td>&gt;16</td>
<td>N/A</td>
<td>N/A</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DSMC</td>
<td>Direct Microscopic Count</td>
<td>&gt;10,000</td>
<td>1,000-10,000</td>
<td>&lt;1,000</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Coliforms</td>
<td></td>
<td>&gt;100</td>
<td>10-100</td>
<td>&lt;10</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sediment</td>
<td>Physical Screen</td>
<td></td>
<td>Subjective</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water Added</td>
<td></td>
<td>Any</td>
<td>None</td>
<td>None</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Mastitis Related:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SCC</td>
<td>Somatic Cell Count</td>
<td>&gt;200,000</td>
<td>100,000-200,000</td>
<td>&lt;100,000</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Staph. aureus</td>
<td>Mastitis Pathogen</td>
<td>&gt;150</td>
<td>50-150</td>
<td>None</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Strep. agalactiae</td>
<td>Mastitis Pathogen</td>
<td>&gt;200</td>
<td>50-200</td>
<td>None</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mycoplasma sp.</td>
<td>Mastitis Pathogen</td>
<td>Any</td>
<td>None</td>
<td>None</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
What now?

• Procedure For Troubleshooting
  ▪ Complete Evaluation of System
    – Physical inspection
    – Wash Analysis
    – Collect data on temperature (wash water, milk, review temperature charts, etc.)
    – What are this dairies counts, what is the history, how do they compare to each other?
      • SPC (Standard Plate Count)
      • PI (Preliminary Incubation Count)
      • LPC (Lab Pasteurized Count)
      • E-coil (Coliform Counts)
      • SCC (Somatic Cell Count)
Using counts together to aid in diagnosis

<table>
<thead>
<tr>
<th>LPC</th>
<th>Coliform Count</th>
<th>LPC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>Low</td>
<td>No Problem</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>Teat Hygiene/Environment</td>
</tr>
<tr>
<td>High</td>
<td>Low</td>
<td>Machine Hygiene</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>Teat Hygiene/Machine Hygiene/Incubation</td>
</tr>
</tbody>
</table>

* Laboratory Pasteurized Count

A 2x2 table of Coliform Count and LPC can be used to localize the source of a high SPC.
**Part 1a. Routine Bulk Tank Milk Quality Analysis**

Bulk tank cultures can be used to diagnose equipment cleaning and sanitation problems, incubation of bacteria in the milk handling system during milking, inadequate pre-milking hygiene, and mastitis. Here is a list of goals, diagnoses and action levels for each type of test.

- **SPC**
  - Good: 1000
  - Warning: 5000
  - Action Needed: 10,000
  - 100,000

- **LPC**
  - Good: 10
  - Dirty Equipment: 50
  - 100
  - 500
  - 1000

- **Coli**
  - Good: 10
  - Dirty Cows: 50
  - Incubation: 100
  - 500
  - 1000

- **SCC**
  - Good: 100,000
  - Warning: 500,000
  - Action Needed: 1,000,000

---

**GEA Farm Technologies – The right choice.**
• Standard Plate Count
  - Improper milking hygiene
  - Inadequate cleaning of equipment and milk tank
  - Inadequate cleaning of non-CIP parts (i.e.: tank valves, etc.
  - Failure to sanitize before milking
  - Improper or inadequate cooling
  - Worn rubber goods
  - Milk filters used for more than 4 hours.
  - Inadequate drainage
  - Large number of mastitis cows (rare)
• Preliminary Incubation Count
  - Dirty milking equipment
  - Dirty udders
  - Improperly sanitized equipment
  - Early fall-off of the milking unit
  - Sediment in milk
  - Cracked and worn rubber goods
  - Poor Udder Preparation
  - Cooling
  - Contaminated water
  - Improper drainage – water sitting in pipeline.
Gasket Needs replacing
• Lab Pasteurized Count
  ▪ Inadequate equipment washing – DIRTY EQUIPMENT
  ▪ Inadequate milk tank washing – DIRTY EQUIPMENT
  ▪ Cracked and worn rubber goods
  ▪ Prevalent when soil visible after wash
  ▪ Biofilms (seen most in extended milking)
Neck of Receiver Jar by Probes
• Coliform Counts
  ▪ Indication of fecal matter in milk
  ▪ Milking wet dirty udders
  ▪ Cow Cleanliness
  ▪ Liner Head Cleanliness
  ▪ Properly set ATO delay and retract
  ▪ Towel sanitation
  ▪ Use of contaminated water

• Somatic Cell Count
  ▪ On rare occasions, the SPC may be elevated due to cows with high SCC caused by streptococcus agalactiae
Coliforms
• Complete Evaluation of System
  ▪ Physical Inspection
    – Pipeline (elbows, tees, unions)
    – Milk units
    – Inflations
    – Weigh jars
    – Sanitary traps
    – Pulsation lines
    – Header tank
    – Swing pipe
• Washing System Performance

- Water Quality
- Requirements of CIP Cleaning
- Evaluating Wash Systems
- CIP Wash Cycles
- Cleaning Recommendations
System Design

Type of system:
Number of units
Shell and liner type:
Take-offs:
Milk line diameter:
Wash line diameter:
Automatic washer type:
Air injector type:
Milk/wash valve type:
Are there restrictors on jetters or jetter hoses?
Are there restrictors on added water line?
Hole size =
• Complete Evaluation of System (cont.)
  
  ▪ Physical Inspection
    – All valves
    – Milk pump seal
    – Plate coolers
    – Detacher sensors
    – Milk hose
    – Pulsation hose
    – Sample valves
    – Butterfly valve (Plug)
• Complete Evaluation of System (cont.)
  - Milk Tank
    - Check interior for cracks
    - Upper walls of tank
    - Milk outlet valve
    - Agitator paddle
    - Agitator seal
    - Measuring stick
    - Sight glass
• Complete Evaluation of System (cont.)
  - Milk Tank
    – Check for proper Cooling
    – Temperature recording charts
    – Compressor run time
    – Blend temperature (< 50° F)
    – Air flow through condensers
<table>
<thead>
<tr>
<th>Location</th>
<th>Color</th>
<th>Texture</th>
<th>Acid Soluble</th>
<th>Detergent Soluble</th>
<th>Chlorine Soluble</th>
</tr>
</thead>
<tbody>
<tr>
<td>Receiver</td>
<td>White</td>
<td>tacky</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Neck of Receiver</td>
<td>Yellow/White</td>
<td>Slimy</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Receiver Gasket</td>
<td>Yellow/White</td>
<td>Slimy</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Gaskets by Milk Pump</td>
<td>Yellow</td>
<td>Slimy</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
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</tbody>
</table>
Observation of CIP Procedures

Does the sanitary trap valve close (trap-out) during the CIP procedure?  Y  N

Is air drawn into units or wash lines at the wash sink?  Y  N

Is the ball removed from the sanitary trap during washing?  Y  N

Do more than 5 gallons of water drain from the balance tank after the wash cycle?  Y  N

Does the milk pump run continuously during the wash cycle?  Y  N

Is there any visible residue on system components?  Y  N
## Water Quality and Quantity

<table>
<thead>
<tr>
<th>Water hardness = 1GPG</th>
<th>Water iron content = PPM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Other Water test results: PPM Buffers</td>
<td>Amount of water used per cycle = gallons</td>
</tr>
<tr>
<td>Is a water softener installed?</td>
<td>Is water softener charged and functioning?</td>
</tr>
<tr>
<td>Water Heater: Temperature = °F</td>
<td>Capacity = gallons</td>
</tr>
<tr>
<td>Wash sink capacity: gallons</td>
<td></td>
</tr>
</tbody>
</table>
• Complete Evaluation of System
  ▪ Check Proper Milking Hygiene
    – Udder and flanks clipped
    – Sanitizer in wash water
    – Use of individual paper towels
    – Dry teats before machine attachment
    – Stripping of foremilk
    – Cleanliness of milker’s hands and outside of claw
Observation of CIP Procedures

- Evaluate if CIP procedures are being followed correctly.
- Always consider the 6 requirements of cleaning when troubleshooting any build-up.
- Check temperature monitoring devices.
- Measure chemical concentrations
- Record temperature of the water returning to the wash sink at the beginning and end of each cycle
- Complete a sketch of the CIP system and flow circuit to document conditions for future reference and consultation
## Requirements for C.I.P. Cleaning

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Icon</th>
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<tbody>
<tr>
<td>Time</td>
<td><img src="image" alt="Time" /></td>
</tr>
<tr>
<td>Temperature</td>
<td><img src="image" alt="Temperature" /></td>
</tr>
<tr>
<td>Water Volume</td>
<td><img src="image" alt="Water Volume" /></td>
</tr>
<tr>
<td>Chemical Balance</td>
<td><img src="image" alt="Chemical Balance" /></td>
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<tr>
<td>Velocity</td>
<td><img src="image" alt="Velocity" /></td>
</tr>
<tr>
<td>Drainage</td>
<td><img src="image" alt="Drainage" /></td>
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</tbody>
</table>

GEA Farm Technologies – The right choice.
Adequate chemical levels, drainage, and temperatures.

Keith L. Engel: GEA Farm Technologies
C.I.P. Wash Cycles

Pre - Wash Rinse

- No chemical
- Circulate and divert
- Starting temperature: 95 – 110° F (35-43° C)

Purpose:

- Removes some soil load - Up to 98%
- Warm the equipment surface
C.I.P. Wash Cycles

Wash Cycle

- Chlorinated alkaline cleaner
- Circulate 8-10 minutes (Make sure to have a minimum of 20 “GOOD SLUGS” in wash cycle!)
- Starting temperature: 160° F (70° C)
- Discharge temperature: 120° F (50° C)
- Wash solution pH: 10 – 11.5 (minimum)
- Active alkalinity: 250 – 350 ppm (minimum) Higher depending system size & run time.
- Active chlorine: 75 – 100 ppm (minimum)

Purpose: Removes Milk Fat, Protein and Minerals.
“Active Alkalinity” Requirements

1 – Small stall barns, no complications = 200 – 250 ppm “Active Alkalinity”, 75 minimum “active chlorine”.

2 – Larger stall barns with 3” milk line or complications (Y line), parlors without meters and without complications = 300 – 350 ppm “Active Alkalinity”, 90 minimum “active chlorine”.

3 – Parlors with meters = 500 – 550 ppm “Active alkalinity” Glass meters (Surge meters) can wash @ 400 ppm “active alkalinity”, 100 minimum “active chlorine”.

4 – Industrial Dairies = *Add 100 ppm “Active Alkalinity” to parlors extended run times or complications (Added to category 2 or category 3 dairies.),

* These are guidelines, the proper level for a system should be benchmarked versus success.

** Make sure detergent used has adequate sequestration to meet dairies water needs (hardness, total dissolved solids (TDS), etc. and possible temperature issues.
C.I.P. Wash Cycles

Acid Rinse

- Acid Rinse
- Circulate 5 minutes
- Starting temperature: 95 – 110° F (35-43° C)
- Acid solution pH: 2.5 – 3 (optimum)

Purpose:

- Removes chlorine/detergent residues
- Remove minerals
- Inhibits bacteria growth
- Increase chemical activity
C.I.P. Wash Cycles

Sanitize Cycle

- Sanitizer (EPA registered product)
- Run cycle 30 minutes before milking
- Circulation time: 5 minutes
- Starting temperature: 95 – 100° F (35-38° C)
- Active chlorine: 100 – 200 ppm (optimum)

Purpose: Kill bacteria
C.I.P. Wash Cycles

Detergents - Basic Ingredients

- Alkalinity emulsifies fats.
- Chlorine peptizes Proteins.
- Sequestration Agents tie up Solids and carry them out.

C.I.P. Cleaning Requirements

- Time
- Velocity
- Temperature
- Volume
- Chemical Balance
- Drainage

C.I.P. Cleaning Cycles

- Pre-Wash Rinse
- Wash Cycle
- Acid Rinse
- Sanitize Cycle
Make sure you have even flow of wash solution through all units.
“Blow By”

Figure 9: Moving the location of the injector may correct a blow-by
Milk Line Slug Flow Analysis

• Set air injector open time

• Check slug velocity and adjust air admission rate

• Set air injector closed (off) time

• Final vacuum recorder testing and unit flow tests
• Make sure you have enough water flow through meters & peripherals.
## Air Injector Calculation

<table>
<thead>
<tr>
<th>Farm Name:</th>
<th>Case Study - Small Scale</th>
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<tr>
<td>Date:</td>
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</table>

<table>
<thead>
<tr>
<th>Slug Speed (ft./Sec.)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Feet of Milk Line/Receiver</td>
<td></td>
</tr>
<tr>
<td>109</td>
<td>Divided by</td>
</tr>
<tr>
<td></td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>4.36</td>
</tr>
<tr>
<td></td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>3.63</td>
</tr>
<tr>
<td></td>
<td>33</td>
</tr>
<tr>
<td></td>
<td>3.30</td>
</tr>
<tr>
<td>Milk line diameter</td>
<td>3</td>
</tr>
<tr>
<td>Minimum Slug Size</td>
<td></td>
</tr>
</tbody>
</table>

*Need a minimum 4 gallon slug to wash a 3 inch line.*

<table>
<thead>
<tr>
<th>Number of receivers</th>
<th></th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Receiver Jar Size</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>15 Divided by 3</td>
<td>equals 5.0</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>15 Divided by 5</td>
<td>equals 3.0</td>
</tr>
</tbody>
</table>

| Slug Size should be between | 4.0 and 5.0 gallons |

<table>
<thead>
<tr>
<th>Restrictor Size</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of unit restrictors</td>
<td>0</td>
</tr>
<tr>
<td>3/16</td>
<td>equals 0.0 gallons/minute</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of unit restrictors</td>
<td>0</td>
</tr>
<tr>
<td>3/16</td>
<td>equals 0.0 gallons/minute</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Added Water line</td>
<td>1</td>
</tr>
<tr>
<td>3/16</td>
<td>equals 18.0 gallons/minute</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Added water line</td>
<td>0</td>
</tr>
<tr>
<td>1/2</td>
<td>equals 0.0 gallons/minute</td>
</tr>
<tr>
<td></td>
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</tr>
</tbody>
</table>

| Total | 18.0 gallons/minute |

<table>
<thead>
<tr>
<th>Total gallons per minute</th>
<th>18</th>
<th>divided by 60</th>
<th>equals 0.30 gallons/second</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Slug Size required</th>
<th>4.0</th>
<th>divided by 0.30 gal/sec.</th>
<th>equals 13.33 OFF Time</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>5</td>
<td>divided by 0.30 gal/sec.</td>
<td>equals 16.67</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Original AI Setting</th>
<th>4.5 ON Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>ON Time = 5.5 seconds</td>
<td></td>
</tr>
<tr>
<td>Off Time = 10 seconds</td>
<td></td>
</tr>
</tbody>
</table>

* Loose wash plug
** Small Universal trap

Gallons/minute

Tight wash plug
Vacuum Levels Equal on both channels

80 feet (24 Meters) divided by 2.75 seconds equals 29 feet/second (8.8 Meters)

Travel Distance divided by time equals feet/meters per second

One vertical division on graph equals one second
Common Problems

• Water Quality, Quantity, & Temperature
  ▪ The concentration of cleaning chemicals may need to be adjusted for hard water
  ▪ Adequate quantity of water so that the wash vat does not suck air.
  ▪ Water temperature.

• Unit Flow Measurement in Milking Parlors
  ▪ Look for uneven distribution of water to the milking units.
Observation of CIP Procedures

• Evaluate if CIP procedures are being followed correctly.
• Check cooling performance by observing blend temperatures and cooling times
• Measure chemical concentrations
• Record temperature of the water returning to the wash sink at the beginning and end of each cycle
• Complete a sketch of the CIP system and flow circuit to document conditions for future reference and consultation
Requirements for C.I.P. Cleaning

Most Common Causes of C.I.P. Cleaning Problems

- Mechanics
- Water Temperature
- Water Quality
- Detergent Dosage/rate
- Milking Hygiene

Optimizing Protocols to Improve Milk Quality

GEA Farm Technologies – The right choice.
5 Things to the Dairy Should Monitor to Maintain Low Counts on your dairy.
1) Do a walk though after starting the wash cycle.

Have whomever starts the wash cycle stick around long enough to make sure:

- All the liners are plugged into jetters properly.
- Observe if water is running through all the units and meters.
- Listen to see if air injector is functioning properly.
- Observe if the milk pump is pumping adequately.
2) Temperature

Monitor Temperature:

- Monitor temperature charts. Benchmark the end wash temperature with the high temperature on the your chart.
- Utilize wash vat temperature recorders when possible.
- Or simply keep a thermometer around and catch the ending wash temperature periodically.
3) Scheduled Maintenance before failure.

- Have replacement schedule for all rubber goods, diaphragms, wash vat drains, chemical peristaltic tubes, etc.
- Record replacing these items so that you can alter your changing schedule if items are wearing out before your regularly scheduled date.
- Clarify who is responsible for this.
4) Monitor Chemical Usage

- Mark detergent, acid, and sanitizer drums weekly so that you can see if chemicals are getting dispensed at your normal usage levels.
- Work with a route person that keeps good records and can recognize if your usage on these items is up or down.
5) Monitor Quality Counts

• Monitor SPC, LPC, PI, Coliform, and SCC counts.
• When they are high something is causing it.
• Use quality history and events at the dairy to troubleshoot high counts quickly.
Reality Checks

Investigations many times include individuals searching for a single cause of the problem.

“While driving to the farm, many times we hope and pray we’ll find something wrong so we can fix it.”

Unfortunately this leads to a band-aid approach and seldom treats the cause of the problem.

A complete evaluation of the system should be done.
Thank-you!

Keith L. Engel
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GEA Farm Technologies