Troubleshooting high bacteria counts in farm milk

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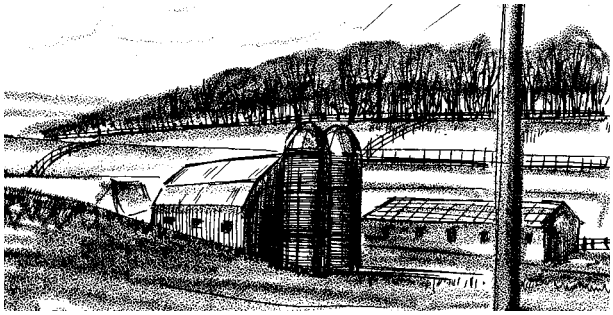


Sources of bacterial contamination in raw milk

Bacteria in raw milk comes from two main sources:

1) organisms transported from the environment into the milking machine; and
2) mastitis organisms from within the udder.

Bacteria deposited in the milking and milk handling equipment multiplies and becomes a major source of contamination if the equipment is not cleaned and sanitized properly. You can clean milk handling equipment effectively by using a combination of chemical, thermal and physical processes. Improper cleaning can result from a failure in any one of these processes. Bacterial growth also occurs during milking and becomes an increasing concern as the length of milking time increases.

The procedures described in this publication are designed to help dairy producers and service personnel identify sources of and eliminate high bacteria count problems in raw milk. The methods presented here deal primarily with diagnosing problems relating to pre-milking cow sanitation and milking equipment cleaning and incubation. Methods for diagnosis and treatment of mastitis problems are covered in detail in other publications.

The form that begins on page 9 may be used as an aid in diagnosis and problem solving. It is not intended that you conduct the entire procedure outlined in the form whenever you encounter a high bacteria problem. Rather, the procedure begins with simple routine testing, which, depending upon the results, may lead to recommendations for more complex and comprehensive testing.

This publication takes you step-by-step through the process of filling out the form and provides supplementary information about each section. You will also find a list of references at the end of this publication for more information.

Routine bulk tank testing (Part 1a)

All farms periodically conduct some form of testing for bacterial contamination to assure compliance with national, state and local milk plant requirements. These tests usually include the Somatic Cell Count (SCC), Standard Plate Count (SPC) and may also include the Preliminary Incubation count (PI) or other tests.

These tests provide an overall measure of milk quality but have little diagnostic value in locating the source of bacterial contamination. We recommend that you perform additional tests to aid in diagnosing the cause of high bacteria counts. Routine bulk tank evaluation can be used to assess the types and levels of mastitis in a herd, the practices of the milkers and the effectiveness of equipment cleaning and sanitation.

Methods for routine bulk tank culture analysis have been presented by Guterbach and Blackmer (1984), and have been adopted by a number of progressive milk processors. These techniques indicate whether high bacterial counts are primarily due to poor pre-milking hygiene, equipment cleaning and sanitation problems, mastitis organisms or incubation of bacteria in the milk handling system. This information is invaluable to the dairy producer and processor.

The recommended tests include:

- **Standard Plate Count (SPC).** The Standard Plate Count is the number of colony forming units in one ml of milk that is plated and incubated for 48 hours at 32°C (90°F). The SPC should be less than 5000 if cow and equipment sanitation is good and cooling is adequate. An SPC of less than 1000 indicates excellence in all of these areas. Most industry standards require an SPC of less than 50,000/ml with 100,000/ml as the federal maximum.
- **Lab Pasteurized Count (LPC).** The Lab Pasteurized Count is the number of bacteria per ml of milk that survive laboratory pasteurization at 62.8°C (143°F) for 30 minutes. This procedure kills the usual mastitis-causing bacteria, leaving only those organisms from the environment that can survive elevated temperatures. These types of organisms will grow and multiply in the milk handling equipment if cleaning and sanitation procedures are inadequate. The LPC should be below 200/ml if equipment cleaning and sanitation are good. A LPC below 10/ml indicates excellent equipment hygiene.
- **Coliform (Coli).** Soil transported from teats and udders into the milking machine is a major source of coliform bacteria in bulk tank milk . The Coli count thus provides an indication of both the effectiveness of cow preparation procedures during milking and the cleanliness of the cows' environment. Coliform counts between 100/ml and 1000/ml are generally an indication of poor milking hygiene. Coliforms will also incubate in residual films left on milk contact surfaces. Coliform counts in excess of 1000 suggest that bacteria have incubated in milk handling equipment. A Coli count less than 100/ml of milk is considered acceptable for raw milk for pasteurization. In states where raw milk may be sold to consumers, Coliform count must be less than 10/ml. Coli counts less than 10 indicate excellence in both pre-milking hygiene and equipment sanitation.
- **Somatic Cell Count (SCC).** Somatic Cell Count is a routine test of the milking herd's milk quality and udder health. High bacteria counts may result when certain types of mastitis organisms such as *Strep. ag.* or *Step. uberis* are present in the herd. A complete bulk tank culture with species differentiation should be performed periodically to determine the type of mastitis organisms present in the milk.

Be particularly careful when you collect and store samples for these tests. Be sure that samples are not contaminated. Store them at temperatures below 4°C (40°F) or freeze them until processed. Do not make a diagnosis based on a single test; take a series of at least three.

If you are concerned about producing quality milk, perform this entire series of tests weekly on large farms and at least monthly on small farms. These tests can help you quickly identify a problem situation before it becomes a crisis, and can provide valuable information for assessing the relative performance of different pre-milking cow preparation methods and different equipment cleaning and sanitation regimes.

Strategic milk sampling (Part 1b)

When routine bulk tank testing indicates that a problem exists, you can perform more detailed tests to further isolate the source of the problem. If the bulk tank analysis in part 1a indicates that equipment sanitation or incubation is the major source of bacteria, proceed with strategic milk sampling to further identify the source.

Strategic sampling of milk at different **times** during the milking process will determine if bacterial incubation in the milk handling system is a major source of contamination.

Strategic sampling of milk in different **locations** will determine if the location of a cleaning failure and/or incubation problem lies in:

- the milking units, milkline and receiver;
- the milk transfer line (including filters and precoolers); or
- the bulk tank.

Observation of CIP procedures (Part 2a)

If milk quality testing in part 1 indicates that there may be equipment cleaning problems, proceed to part 2b to identify the specific cause. Concentrate your observations on those parts of the system indicated by strategic milk sampling.

A standard part of the assessment of any cleaning regime is to document the "as found" and "as practiced" conditions. The purpose of part 2a is to help you determine if the recommended CIP procedures are being followed correctly.

Every milking system should have a set of written instructions for the CIP process. This should include the recommended cycles with the time, temperature and chemical concentration specified for each cycle. If these instructions have not been provided by the equipment and chemical consultant, this part of the form can be used to provide them. Make sure that all personnel are aware of, and trained in, recommended CIP procedures. Different hardware and procedures are usually used for cleaning the milking machine and the bulk milk storage tank.

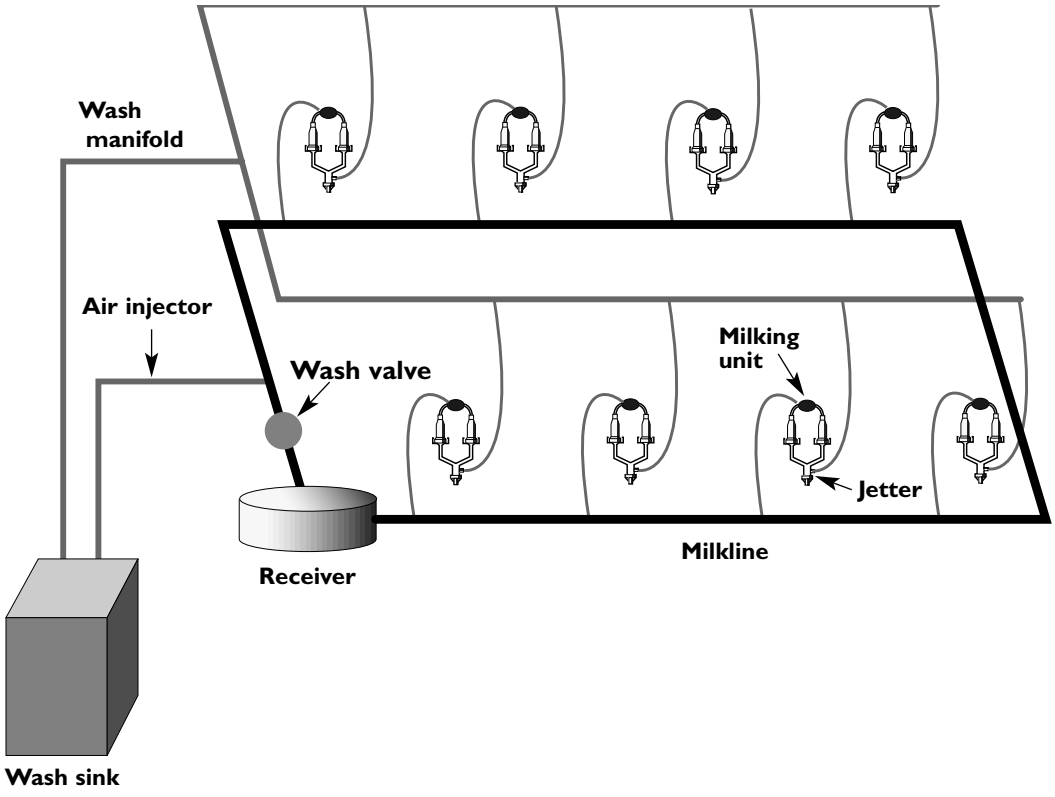
Observe one complete cleaning to document the cycles used. Record the chemical concentrations and temperature of the water returning to the wash sink at the beginning and end of each cycle. Obtain the best information available about how often each cycle is applied. See figure 1 for a sample of the components of a clean-in-place system.

Cleaning cycles can be missed routinely or skipped to save time when things get busy. Newer automatic washers can record whether cleaning cycles actually occurred and the temperature of each cycle.

The four cycles used in most cleaning regimens in the U.S. are described below.

1. An **initial rinse** is performed immediately after milking to remove milk that remains in the system. The temperature of this rinse should be between 100˚F and 130˚F. The upper limit has been chosen in the belief that proteins may be "baked" on to surfaces at temperatures in excess of 140˚F. The lower limit is set above the melting point of butterfat to ensure that fats will be removed and not redeposited. A benefit of increasing the rinse temperature is that it reduces the temperature drop during the subsequent detergent wash cycle. If dropping temperatures during the detergent cycle are a problem, consider increasing the rinse temperature to the upper end of this limit. Do not recirculate water used in the initial rinse.

Figure 1. Example of milking parlor CIP system.



2. A **detergent wash cycle**, usually containing a chlorinated, alkaline detergent, removes organic soils such as milkfat and proteins. Consult the label instructions to assess whether "as found" practices fall within these recommendations. Most detergents work at a temperature range between 43˚C and 77˚C (110˚F and 170˚F). The range should be specified on the label. If organic film is present, consider raising the temperature to the upper limit of this range. Cleaning effectiveness improves as the temperature goes up. You many need to adjust detergent concentrations to account for water hardness; this information should also be indicated on the product label.
3. An **acid rinse cycle** may be performed to remove mineral deposits left by milk and hard water. The low pH environment created by the acid rinse also inhibits growth of bacteria when the milking equipment is not in use. The temperature of this rinse is typically 38˚C to 49˚C (100˚F to 120˚F) but may be a cold rinse depending on the product used. The product label should specify the recommended concentration and temperature.
4. A **sanitizing cycle** is performed immediately before milking, usually with a chlorine-based product. This kills any bacteria in the milking system that have survived the cleaning process. Recommended temperatures for this cycle range from 35˚C to 43˚C (95˚F to 110˚F) and should be noted on the product label.

It is the chemical consultant's responsibility, based on the water volume and results of water quality tests, to prescribe the amount of chemical and temperature to use for each cycle. The chemical consultant should be trained and equipped to perform water quality tests, measure water temperatures and volumes and determine if the appropriate chemicals are being used. Clean by hand the exterior surfaces of milking units and any parts of the milking machine that may contact milk and are not part of the CIP circuit. Do not use detergents designed for circulation cleaning when you hand clean.

Shock treatment. Some systems use "shock" treatments periodically to reduce bacteria counts. This procedure is commonly performed using a higher-than-usual concentration of chemicals. Shock treatments shorten the life of equipment. They are also expensive and dangerous and do not correct the source of the problem. Shock treatments should not be required if the cleaning system is operating properly.

Residual films. Cleaning failures usually result in a buildup of residual film you can see on some parts of the milk harvesting or storage equipment. Some of these films have a characteristic appearance that can help you determine why the cleaning failure occurred.

There are two broad categories of residual films: 1) organic films such as fat and protein; and 2) inorganic films such as hard water minerals, iron and silica. Discoloration may also occur due to corrosion and/or pitting of surfaces. Protein films can appear as a brownish slime when wet. Mineral films usually have a rough porous texture and are invisible when wet. Organic films are generally alkaline-soluble while inorganic films are generally soluble in acid. Protein films dissolve in chlorine. Films can be diagnosed by scrubbing a small area with concentrated acid and/or detergent solutions.

Drainage. Improper drainage is a common source of bacterial contamination and mixing of cleaning solutions, thus reducing the solutions' effectiveness. All parts of the milking system (both sanitary and non-sanitary) should drain when the system is shut off. Inspect the milking system for any pipes, hoses, fittings and equipment that do not drain when the system is shut off.

Other parts of the system. The "non-sanitary" parts of the milking machine may also be a source of bacterial contamination. If milk quality tests indicate an equipment cleaning and sanitation problem in the milking machine and the source cannot be found in the milking units, hoses, milkline or receiver, perform a visual inspection of air lines and ancillary equipment such as backflush systems. These non-sanitary parts of the system should be cleaned periodically as part of the system's routine maintenance. The seals and gaskets and all rubber goods should be changed at least annually. Aged rubber becomes porous and is very difficult to clean.

Milk temperature. The temperature of the milk at various points in the system will help determine if the cooling system is operating correctly. Inadequate cooling will increase bacteria counts by allowing a better environment for bacteria growth during storage. Milk should be cooled to 4.4˚C (40˚F) or below within 30 minutes of milking and held between 0 and 4.4 ˚C (32˚ and 40˚F) until pasteurized. If milk is not mixed adequately in the storage tank, temperature stratification may occur and reduce the effective cooling of the upper layers of milk.

Observation of CIP flow dynamics (Part 2b)

A cleaning failure will take place if cleaning solutions are not adequately distributed to all parts of the milking system. If the cleaning solution does not reach surfaces that come into contact with milk, the desired chemical and thermal actions cannot take place. Part 2b provides a way to conduct an initial assessment of the water and airflow dynamics of a milking CIP system. These observations and measurements can be performed without special test equipment (vacuum recorder, vacuum gauge and airflow meter). Conduct these observations if milk quality tests indicate a cleaning problem in the milking machine but all cleaning cycles appear to function properly.

The first step in assessing flow dynamics is to understand the intended flow circuit. A sketch of the CIP system will aid in understanding the flow circuit and document conditions for future reference and consultation with equipment service personnel. The sketch should indicate the diameter and length of all lines and locations of critical components such as receiver(s), wash sink(s), air injector(s), wash valve(s) and any other equipment that is cleaned or used for cleaning. Document the location of any manual or automatic valves that may be operated before or during the wash cycle, and check whether air is being drawn in at the wash sink. Also check the timing of the air injector.

Flow problems commonly result from improper air injector location and/or timing cycles. This can be a problem in round-the-barn (RTB), highline systems and milking parlors. The usual result is a flooded system. Some symptoms of improper air injector location and/or timing occur when:

- the system "traps out" (the ball valve in the sanitary trap shuts off system vacuum during one or more wash cycles);
- air is drawn into the system at the wash sink. When air is drawn into water draw lines or milking units at the wash sink, the system has an uncontrolled point of air injection.
- the milk pump never shuts off during the cleaning cycle; and
- a large volume of water drains from the distribution tank when the vacuum pump is shut off after cleaning.

If these initial tests indicate that a flow problem may exist, you should perform a complete flow evaluation. Do not make any changes to the CIP system (such as changing air injector timing or changing any hardware) without the proper test equipment to properly assess their effects. A qualified service person with appropriate test equipment and training should be consulted for a complete flow analysis (see parts 3, 4 and 5). The installation and commissioning of every milking system should include installation of the equipment and adjustment of the controls to circulate solutions properly throughout the milking system.

A complete CIP flow analysis should be conducted whenever:

- a new system is installed;
- a change is made to an existing system; or
- milk quality tests indicate a cleaning problem and the recommended CIP procedures are being followed.

Water quantity and quality (Part 3)

Air being drawn into the milking units or draw lines at the wash sink may be caused by flooding of the milking system (usually a result of improper air injection) or because of inadequate water volume. The minimum water volume required for proper flow dynamics can be estimated using the table in Part 3. This table can be used to determine if the minimum water volume is available for each wash cycle and to determine if water and chemical costs can be reduced by improving the configuration or flow dynamics of the CIP system.

Chemical cleaning concentration may need to be adjusted for hard water. Record the water hardness to determine the appropriate concentrations.

Unit flow in milking parlors (Part 4)

A common problem in milking parlor systems is uneven distribution of water to the milking units. Visual indicators of low flow in a milking unit/jetter combination include:

- reverse flow in jetter hoses; and
- a milking unit claw that never floods during the cleaning cycle.

The flow rate through milking units and milk meters can be measured using the method illustrated in figure 1. Document the flow in the first, last and middle units and any units that appear dirty.

Ideally, flow should be uniform through all milking units in the parlor. Field studies indicate that 3 L/min (0.8 gallons/min) is sufficient to clean most milking units. While many units clean at flow rates below this value, the risk of cleaning failure is increased. Milk meters and weigh jars may require water flow rates of 4.5 to 6 L/min (1.2 to 1.6 gallons/min) to clean effectively.

Install flow restrictors at each jetter to balance the flow. Changing the flow rate to the milking units or milk meters may require an adjustment to the air injector timing and/or water volume required per cycle. Do not change either of these without contacting the service person and/or chemical consultant.

Milkline slug flow dynamics (Part 5)

Proper test equipment is required to properly diagnose CIP circulation problems. Only a qualified service technician with the proper test equipment should attempt to set up and troubleshoot CIP flow dynamics.

A vacuum recording device, commonly used to evaluate milking performance, is an essential piece of test equipment required to assess air injected slug flow during cleaning. More detail on diagnostic methods using a vacuum recorder for CIP analysis is given in the references. The following procedure has been developed to set air injector timing and diagnose faults.

1) **Set air injector open time.** The air injector open time is a relatively easy number to calculate and should be the first step in setting up an optimal cleaning cycle. The length of time that the air injector is open, together with slug velocity, determine the travel distance of the slug. The slug formed at the point of air injection should travel to the receiver without breaking. **Measure the distance that the slug must travel from the point of air injection to the receiver.** Divide the slug travel distance by the desired slug velocity to determine the air injector open time. Slug velocity for optimal mechanical action is between 7 and 10 meters per second (23 and 33 feet per second).

2) **Check slug velocity and adjust air admission rate.** Slug velocity should be measured using a vacuum recorder and the air admission rate adjusted to achieve the desired velocity. The rate at which air is drawn in through the air injector determines the travel speed of the slug. The physical connection to the milkline for vacuum measurement is best done with a tee inserted in-line with a milk hose near the milk inlet. Sections of transparent tubing 10 to 20 feet in length should be used to connect to the recorder. Observe these tubes closely and bleed them often to prevent water from reaching the recorder. To minimize the risk of water entering the vacuum recorder, it is advisable to leave the hoses detached except when a measurement is being taken. Moisture traps will fill with water very quickly and are not recommended. The following information can be obtained from these vacuum recordings:

   Slug velocity: Slug velocity can be calculated by dividing the slug travel distance between the two measurement points by the time between vacuum drops. The tests points should be at least 30 feet apart for an accurate measurement.

   Vacuum drop: A rapid vacuum drop is measured when the slug passes the test points. The vacuum drop across a slug is a measure of the mechanical cleaning action produced. The recommended range of vacuum drop across the slug is given in table 1. The vacuum drop should be near the maximum of the range at the beginning of slug travel. This vacuum drop across the slug will decrease slowly as it travels through the line due to slug decay and air entrainment. Inadequate vacuum drop across the slug indicates that the slug is very short and/or that

Table 1. Recommended range of vacuum drop across the slug

Milkline diameter	Vacuum drop	
48 mm (2 in)	5.3 to 11 in. Hg	18–38 kPa
60 mm (2.5 in)	4.4 to 9.5 in. Hg	15–32 kPa
73 mm (3 in)	3.8 to 8.6 in. Hg	13–28 kPa
98 mm (4 in)	3.2 to 7.1 in. Hg	11-24 kPa

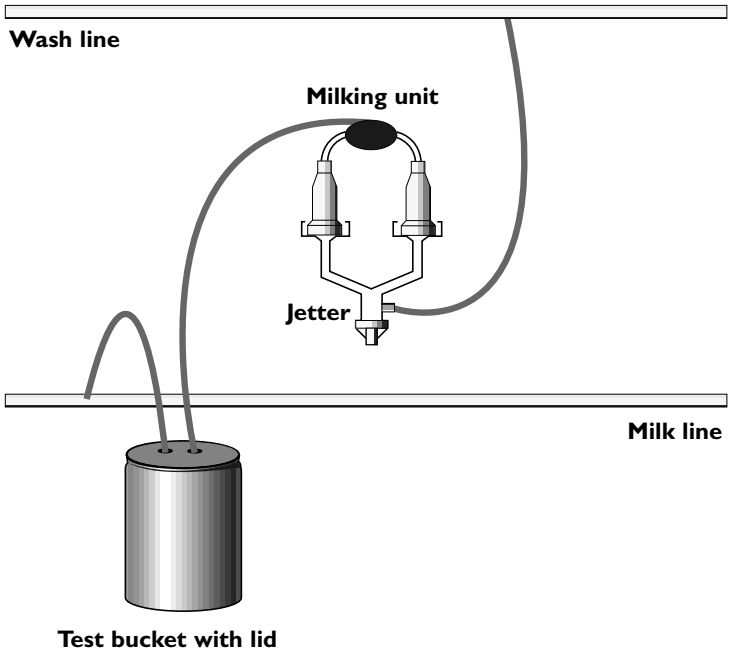
excessive air is passing through the slug. A slow rate of vacuum drop indicates that the slug is moving slowly, usually because of excessive water in the pipeline or an excessively leaky milk/wash valve.

3) **Set air injector closed (off) time:** The amount of water drawn in during each cycle is determined by the amount of time the air injector is closed or off. If the sanitary trap is flooding or excessive water is being transferred through the trap, reduce the closed time. The closed time should be adjusted so the size of the slug reaching the receiver is just sufficient to wash the receiver. If the close time is reduced to the minimum value available on the controller and flooding still occurs, the capacity of the milk pump may need to be increased. Many parlors have an additional pipe to supply water to the milkline in addition to that supplied by the milking units. The water flow through these pipes should be restricted in most applications to avoid flooding the system. Independent control of water and airflow is required to achieve proper slug velocity and water draw rates.

4) **Final vacuum recorder testing and unit flow tests.** After the system has been adjusted according to steps 1 to 3, repeat vacuum recorder testing of slug flow. Check the vacuum drop at the beginning, end and other critical locations in the milkline. Perform a fine adjustment of the air injector at this time. The air injector should close just before the slug hits the receiver jar. If the air injector remains open after the main slug reaches the receiver, excessive water may be carried through the sanitary trap. After fine adjustment of the air injector, recheck unit flow at critical locations including the first, last and middle units on both sides of the parlor, and on any units with visible buildup.

Sequenced air injection: Air injection is not required to clean most commercial milking units. If these components are not present, air injection should be used only on the milkline as shown in figure 2. If air injection is supplied to both the milkline and the wash manifold, two air injection points should be used with the injection sequenced so that both injectors are not open at once. Air injection should be used on the jetter line only if difficult-to-clean components such as weigh jars or some milk meters are present. Optimal air injector timing is usually different for wash manifolds than for the milk line. Sequenced air injection allows for optimization of both, thus improving cleaning action in the milking system as well as reducing vacuum pump requirements. Further details on sequenced air injection are provided in reference 4.

Figure 2. Unit flow measurement for milking parlors.



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Troubleshooting high bacteria counts in farm milk

General information

Operator_____ Phone_____ Date_____

Address_____

Equipment Dealer_____

Phone_____

Chemical supplier_____ Phone_____

Prioritized recommendations

_____

_____

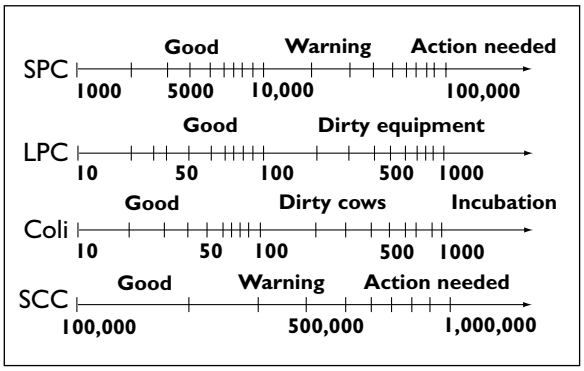
_____

_____

System sketch

Part 1a Routine milk quality analysis

Bulk tank cultures can be used to diagnose: 1) equipment cleaning and sanitation problems; 2) bacterial incubation in the milk handling system during milking; 3) inadequate pre-milking hygiene; and 4) mastitis.



In general:

- Equipment cleaning and sanitation problems typically result in elevated LPC counts.
- Incubation of bacteria in the milking system cause elevated Coli (above 1000) **and** LPC counts.
- Inadequate premilking hygiene will result in elevated Coli counts (typically 100 to 1000).
- If both SCC and SPC are high, mastitis organisms may be the cause of high bacteria counts.

Take composite milk samples from the bulk tank at the time the milk is shipped from the farm. Perform the tests indicated above on a routine basis a minimum of monthly on small farms and weekly on large farms and more often if a problem situation exists. A minimum of three tests is needed to make a diagnosis. Record the culture results and test dates below.

	Date					
SPC: Standard Plate Count						
LPC: Lab Pasteurized Count						
Coli: Coliform Count						
SCC: Somatic Cell Count						

Part 1b Strategic sampling

If routine bulk tank analysis indicates that equipment cleaning and sanitation may be a problem it is desirable to further diagnose the source of the problem. Take milk samples from the receiver(s), transfer line(s) and bulk tank after the first group of cows is milked (one cow for each milking unit) and after every four hours of milking (or since the system has been washed) taking a final sample at the end of milking (or before the next wash cycle). Record the results of these tests in the following table.

- Elevated counts in the receiver samples at the beginning of milking likely indicate a cleaning problem in the milking units, milk meters, milkline or hoses. If this situation exists, perform the CIP flow analysis.
- Elevated counts in transfer lines but not in receivers after the first group of cows indicates cleaning failure in the transfer line and equipment between the receiver and bulk tank such as plate coolers and milk filters.
- A continual rise in counts during milking indicates bacterial incubation as the likely cause. Solutions to this problem may include replacing rubber goods, washing the system more thoroughly and frequently changing the milk filter .

SPC	**After first group of cows**	**After 4 hours**	**After 8 hours**	**End of milking**
Time of sample				
Receiver 1				
Receiver 2				
Transfer line 1				
Transfer line 2				
Bulk tank 1				
Bulk tank 2				

CIP procedures observations — Part 2a

Yes **No** Does the sanitary trap valve close (trap out) during the CIP procedure?

Yes **No** Is air drawn into units or wash lines at the wash sink?

Yes **No** Is the ball removed from the sanitary trap during washing?

Yes **No** Does more than 5 gallons of water drain from the balance tank after the wash cycle?

Yes **No** Does the milk pump run continuously during the wash cycle?

Yes **No** Is there any visible residue on system components?

Describe: **Location**	**Color**	**Texture**	**Acid Soluble**	**Detergent soluble**	**Chlorine soluble**

Yes **No** Is the system "shock" treated? **If yes**, how often? (Note shock treatment dates on bulk tank culture record).

_____

Yes **No** Do any system components fail to drain after the CIP procedure? **If yes**, indicate which.

_____

Yes **No** Are any valves actuated manually before or during the CIP procedure? **If yes**, indicate valve on the system sketch.

_____

Milk temperature: Entering bulk tank _____ At end of milking _____
At pickup: top of tank _____ At bottom of tank _____

	Premilking sanitize	**Prewash rinse**	**Detergent wash**	**Acid rinse**	**Other**
Start temp					
End temp					
Cycle time					
Product used					
Label concentration					
Label temperature					
Concentration used					
Other measurements (pH, alkalinity, etc.)					
Guidelines	Follow label instructions for time, temperature and concentration	43°–54° C (100°–130° F)	Follow label instructions. 6-10 min., typical 49°–77° C (120°–170° F)	Follow label instructions 2 min., typical 32°–43° C (90°–110° F)	

Part 2b CIP system design

Sketch the milking machine CIP system on page 1.

Measure the length and diameter of all lines and indicate the location of air injector(s).

Type of system: ❑ Parlor ❑ Round-the-barn

Number of units _____

Claw type _____

Shell and liner type _____

Milk meters or weigh jar type _____

Other equipment _____

Automatic washer type _____

Washline diameter(s) _____

Automatic washer type _____

Air injector type(s) _____

Milk/wash valve type: ❑ paddle ❑ butterfly ❑ plug

Y **N** Restrictors on jetters or jetter hoses?
Hole sizes _____

Y **N** Restrictors on wash lines?
Hole size _____

Date of last liner change _____

How often are liners changed? _____

Date of last change of hoses and other rubber parts _____

Other CIP system characteristics _____

_____

_____

_____

_____

_____

_____

_____

Water quantity and quality Part 3

Water hardness _____

Water iron content _____

Y **N** Is a water softener installed?

Y **N** Is water softener charged?

Other water test results _____

Water heater	Temperature	Capacity
Tank 1		
Tank 2		
Tank 3		
Wash sink		

Determine the minimum water volume required per wash cycle for proper flow dynamics in air-injected milking systems. Use this estimate to size wash sinks in new systems or to check if the actual water used per cycle is higher or lower than the minimum requirement. The requirement for milk meters, wash vat and precoolers are approximate and may vary with different component designs. If air injection is not used, multiply the total gallons for the milkline by 3. If weigh jars are used, multiply the milk meter gallons by 4.

		(x) Multiplier	**(=) Gallons**
Feet of milkline			
	Line diameter 4 in.	**x** 0.12	**=**
	Line diameter 3 in.	**x** 0.07	**=**
	Line diameter 2.5 in.	**x** 0.05	**=**
	Line diameter 2 in.	**x** 0.03	**=**
	Line diameter 1.5 in.	**x** 0.02	**=**
Feet of wash draw and milk transfer line			
	Line diameter 3 in.	**x** 0.34	**=**
	Line diameter 2.5 in.	**x** 0.23	**=**
	Line diameter 2 in.	**x** 0.15	**=**
	Line diameter 1.5 in.	**x** 0.09	**=**
Receiver(s) Volume (gallons)			
		x 0.33	**=**
Number of milking units			
		x 0.25	**=**
Number of milk meters			
		x 0.25	**=**
Feet of milk hose			
	Hose diameter 9/16 in.	**x** 0.012	**=**
	Hose diameter 5/8 in.	**x** 0.016	**=**
Number of precoolers			
		x 2	**=**
Number of wash vats			
		x 8	**=**
		Total gallons	**=**

Part 4 Unit flow measurement for milking parlors

Measure unit flow at the first, middle and last unit on each side of the parlor. Also measure any units that appear dirty. Unit flow analysis units should have no less than 3 L/min with no more than 50% variation between the highest and lowest units. Higher flow rate may be required to clean some components such as milk meters or weigh jars. Consult manufacturer's recommendations.

Unit number (*refer to sketch*)	**Restrictor type and size**	**Water volume** (*liters or lbs*)	**Time of sample** (*min*)	**Average flow rate** (*L/min or lb/min*)
As found				
After change				

Estimate air injector open time	**Injector 1**	**Injector 2**
Slug travel distance from air injector through air injector line and milkline to receiver *(feet or meters)*		
Expected air injector open time: divide slug travel distance by 28/ft/sec (8.5 m/s) or other slug speed *(seconds)*		
Estimate expected time between vacuum drop at test points	**Injector 1**	**Injector 2**
Distance between test points (points at which vacuum recorder attaced to milkine *(feet or meters)*		
Time between vacuum drops: divide distance between test points by 28 ft/sec (8.5 m/s) or other slug speed *(seconds)*		

Vacuum drop and slug speed measurements: Attach vacuum recordings to form

			If sequenced		Time between vacuum drop at test points		Slug speed		Vacuum drop at test points			
	Injector closed	Milkline injector open	Washline injector open	Injector airflow rate setting	Loop 1	Loop 2	Loop 1	Loop 2	Loop 1, Point 1	Loop 1, Point 2	Loop 2, Point 1	Loop 2, Point 2
As found												
1st adjustment												
2nd adjustment												
3rd adjustment												
Final setting												
Guideline	Long enough to form a slug	Just long enough to move slug to receiver	Just long enough to clear wash line	Adjust air flow rate to change slug speed			23–33 ft/sec, 7–10 m/s		4–9 in. Hg (12–30) for 3 in. line 5–7 in. Hg (18–25kPa) for 2 in. line			

Vacuum drop at other locations

Location (refer to sketch)											
Vacuum drop											

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