# TROUBLESHOOTING HIGH BACTERIA COUNTS IN FARM MILK

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## Sources of Bacterial Contamination in Raw Milk

The two main sources of bacteria in raw milk are mastitis organisms from within the udder and organisms transported from the environment on the surface of the teats. Bacteria deposited in the milking and milk handling equipment will multiply and become a major source of contamination if this equipment is not cleaned and sanitized properly. Cleaning of milk handling equipment is accomplished by a combination of chemical, thermal and physical processes. A cleaning failure can result from a failure in any one of these processes.

This procedure is designed to help dairy producers and service personnel identify sources and resolve high bacteria count problems in raw milk. The methods presented deal primarily with the diagnosis of 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 accompanying form is to be used as an aid in diagnosis and problem solving. It is not intended that the entire procedure will be implemented whenever a high bacteria problem is encountered. The procedure is intended to begin with simple routine testing and provide recommendations to proceed in a logical fashion to the more difficult and comprehensive testing based on test results and interpretation.

## Routine Bulk Tank Testing (Part 1a)

Some form of testing for bacterial contamination is done periodically on all farms 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 they have little diagnostic value in determining the source of bacterial contamination. If a routine bulk tank sample indicates a bacteria problem (high SPC or PI), the first step in determining the cause of the problem is to perform a more thorough analysis of bulk tank milk. 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). These methods have been adopted by a number of progressive milk processors. These tests and interpretation methods provide an indication of whether high bacterial counts are due to mastitis, pre-milking hygiene, equipment cleaning and sanitation, or incubation of bacteria in the milk handling system during milking. This is invaluable information 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 when incubated for 48 hours at 32 C (90 F). The SPC should be less 5000 if cow and equipment sanitation is good and cooling is adequate. A SPC of less than 1000 indicates excellence in all of these areas. Most industry standards require a SPC of less than 50,000.

High bacteria counts may result from *Strep. ag*. mastitis infection in the herd. If the SCC and SPC are both high, a thorough bulk tank culture should be performed to determine the type of mastitis organisms present in the milk. This information is useful to manage mastitis in the herd. Other types of bacteria represent contamination from the environment. These organisms are transported during milking from the skin of the udder into the milk and onto milk handling equipment. These bacteria multiply during the milking process and may continue to multiply between milkings if they are not removed or killed.

**Lab Pasteurized Count** (LPC): The Lab Pasteurized Count is the number of bacteria per ml of milk which 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 which 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 100 to 200 if equipment cleaning and sanitation are good. A LPC below 10 indicates excellent equipment hygiene.

**Coliform** (Coli): The major source of coliform bacteria in bulk tank milk is transportation on the udders of cows from the environment. 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 and 1000 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 incubation in milk handling equipment. A Coli count less than 100 per 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 premilking hygiene and equipment sanitation.

Another test which indicates the cleanliness of cows when they are being milked is the sediment in the bulk tank milk. A sediment level less than 1.50 mg per gallon is considered acceptable.

It is particularly important to exercise care in the collection and storage of samples for these tests. Samples should be taken so that they are not contaminated and stored below 40 F or frozen until processed. It is not advisable to perform diagnosis based on a single test. A series of at least three tests should be performed. For those producers concerned with producing quality milk, the entire series of tests should be performed weekly on large farms and at least monthly on small farms. These tests can help to quickly resolve crisis situations and, for the quality-conscious producer, can also provide valuable information to assess the relative performance of different pre-milking cow preparation methods and different equipment cleaning and sanitation regimes.

**Strategic Milk Sampling** (Part 1b)

When the routine bulk tank testing indicates that a problem exists, more detailed tests can be performed to further isolate the source of the problem and recommend the most expedient and effective methods to solve it. 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 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 is:

**1)** in the milking units, milkline and receiver,
**2)** in the milk transfer line (including filters and pre-ccolers)
**3)** or in 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 2 to identify the specific cause of a cleaning and sanitation failure. Concentrate 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 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, the recommended CIP procedures. Different hardware and procedures are usually used for cleaning the milking machine and the bulk milk storage tank.

It is advisable to observe one complete cleaning to document the cycles which are used and obtain the best information available as to the frequency of application of each cycle. The temperature of the water returning to the wash sink should also be recorded at the beginning and end of each cycle. Cleaning cycles are sometimes missed either as a routine practice or to save time when things get busy. Newer automatic washers can record whether cleaning cycles actually occurred and the temperature of each cycle. There are four parts to most cleaning regimes used in the U.S.:

**1.** An initial rinse is performed immediately after milking is completed, to remove most of the residual milk remaining in the system. The temperature of this rinse should be between 95 and 130 F. The upper limit has been specified in the belief that proteins may be 'baked' on to surfaces. 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 to reduce the temperature drop during the subsequent detergent wash cycle. If temperature drop during the detergent cycle is a problem, consider increasing the rinse temperature to the upper end of this limit.

**2.** A detergent wash cycle, usually with a chlorinated, alkaline detergent, is performed to remove organic soils such as milk fat and proteins. Consult the label instructions to assess whether 'as found' practices fall within these recommendations. Most detergents have a working temperature range between 110 F and 170 F which should be specified on the label. If organic films are present, consider raising the temperature to the upper limit of this range. Cleaning effectiveness improves as temperature is increased. Detergent concentrations may need to be adjusted 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 from milk and hard water. The low pH environment created by the acid rinse also inhibits growth of bacteria during the time the milking equipment is not in use. This may be a cold or warm rinse. The recommended concentration and temperature should be specified on the product label.

**4.** A sanitizing cycle is performed immediately before milking, usually with a chlorine-based product. This is to kill any bacteria in the milking system which have survived the cleaning process. Recommended temperatures are typically 95 - 110 F and should be noted on the product label.

It is the responsibility of the chemical consultant to prescribe the amount of chemical and temperature to be used for each cycle based on the water volume and results of water quality tests. 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.

**Shock Treatment:** Some systems use "shock" treatments periodically to reduce bacteria counts. This procedure is commonly performed using 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 visual buildup or residual film on some part of the milk harvesting or storage equipment. Some of these films have a characteristic appearance which, if identified, can help determine the cause for the cleaning failure. There are two broad categories of residual films: Organic films such as fat and protein, and 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 (applesauce) when wet. Mineral films usually have a rough porous texture and are invisible when wet. Organic films are generally alkaline soluble whereas inorganic films are generally acid soluble. Films can be diagnosed by scrubbing a small area with concentrated acid or with alkaline detergent solutions.

**Drainage:** Improper drainage is a common source of bacterial contamination. All parts of the milking system (both sanitary and non sanitary) should drain when the system is shut off. The milking system should be inspected 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, a visual inspection of pulsator and other airlines or ancillary equipment such as backflush systems should be performed. These non-sanitary parts of the system should be cleaned periodically as part of routine maintenance of the system. The seals and gaskets should be changed regularly to avoid contamination of these parts of the system.

**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 result if cleaning solutions are not adequately distributed to all parts of the milking system. If little or no cleaning solution comes into contact with any milk contact surface the chemical and thermal actions cannot take place. Part 2b is an initial assessment of the water and air flow dynamics of a milking CIP system. These observations and measurements can be performed without special test equipment (vacuum recorder, vacuum gauge and airflow meter). These observations should be performed if milk quality tests indicate a cleaning problem in the milking machine and all cleaning cycles have been observed to be executed 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 as well as document conditions for future reference and consultation with equipment service personnel. The sketch should indicate the diameter and length of all lines and location of critical components such as receiver(s), wash sink(s), air injector(s), wash valve(s) and any other ancillary equipment that is cleaned or used for cleaning. Document the location of any manual or automatic valves which may be operated before or during the wash cycle, whether air is being drawn in at the wash sink, and 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 both 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 are:

**1.** The water level in the receiver does not change during the cleaning cycle

**2.** The milk pump never shuts off during the cleaning cycle.

**3.** The system 'traps out' (the ball valve in the sanitary trap shuts off system vacuum during one or more wash cycles)

**4**. A large volume of water drains from the distribution tank when the vacuum pump is shut off after cleaning.

**5.** Air is drawn in to 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.

If these initial tests indicate that a flow problem may exist, a complete flow evaluation should be performed. Changes to the CIP system, such as changing air injector timing or changing any hardware, should not be done 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 (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 throughout the milking system for effective cleaning. 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.

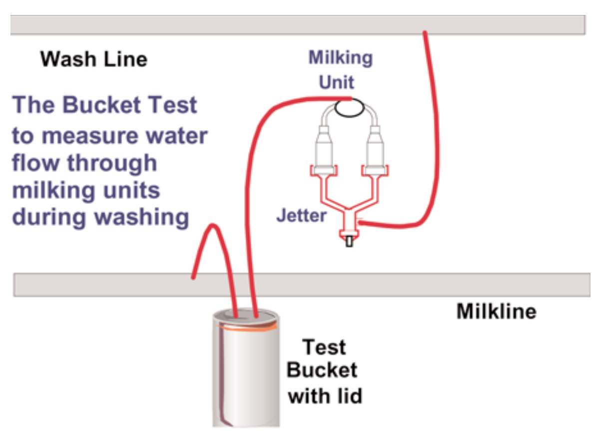
**Water Quantity and Quality** (Part 3)

Air 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 flow dynamics of the CIP system.

Cleaning chemical concentration may need to be adjusted for hard water. Record the water hardness to determine if the chemical concentrations are appropriate.

**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 Milking unit claw never floods during cleaning cycle. The flow rate through milking units and milk meters can be measured using the method illustrated here. Document the flow in the first, last and middle units and any units that appear dirty. Parlors should ideally



have uniform flow through all milking units. Preliminary results from field studies indicate that 0.8 gallons per minute (3 L/min) is sufficient to clean most milking units. While many units will clean at flow rates below 0.8 gpm (3 L/min), the risk of cleaning failure appears to be increased. Some milk meters may require water flow rates higher than 3 L/min for effective cleaning.

Flow restrictors should be installed at each jetter to balance the flow. Flow restrictors should not be placed in the washline feeding the jetters. 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 consulting the service person and/or chemical consultant.

**Milkline Slug Flow Dynamics** (Part 5)

Proper test equipment is required to properly diagnose CIP circulation problems. Setup and troubleshooting of CIP flow dynamics should only be attempted by a qualified service technician with the proper test equipment. A vacuum recording device, commonly used to evaluate milking performance, is a essential test equipment to assess air injected slug flow during cleaning. More detail on diagnostic methods using a vacuum recorder for CIP analysis are 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 setup of 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. Use a value of 28 feet per second unless the system configuration would warrant a different speed. Slug velocity for optimal mechanical action is between 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 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. These tubes should be observed closely and bled 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 gained 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 are given below. 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.

| **Recommended range of vacuum drop across the slug.** | |
|---|---|
| Milkline Diameter | Vacuum Drop |
| 2" | 5.3 - 11 "Hg |
| 2.5" | 4.4 - 9.5 "Hg |
| 3" | 3.8 - 8.6 "Hg |
| 4" | 3.2 - 7.1 "Hg |

Inadequate vacuum drop across the slug indicates that the slug is very short (less than 3 ft) and/or that 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, the closed time should be reduced. 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 air flow 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 for the presence and strength of slug at the beginning, end and other critical locations in the milkline. Fine adjustment of the air injector should be performed 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:** For systems with more than one air injector, air injection should be sequenced so that both injectors are not open at once. 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.

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