THE DAIRY PRACTICES COUNCIL®

GUIDELINE FOR THE DESIGN, INSTALLATION, AND CLEANING OF SMALL RUMINANT MILKING SYSTEMS

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EXCEPTIONS FOR INDIVIDUAL STATES NOTED IN TEXT OR FOOTNOTES
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Guideline Preparation and Review Process

Guideline development within Dairy Practices Council (DPC) is unique and requires several levels of peer review. The first step in the process of guideline development starts with a Task Force subcommittee comprised of individuals from industry, regulatory and education interested in and knowledgeable about the subject to be addressed. Drafts, referred to as 'white copies,' are circulated until all members are satisfied with the text. The final white copy may then be distributed to the entire Task Force, DPC Executive Vice President and whoever the Task Force Director feels would add to the strength of the review. Following final white copy review and correction, the next step in the process requires a yellow cover draft that is circulated to the member Regulatory Agency representatives that are referred to as "Key Sanitarians." The Key Sanitarians may suggest changes and insert footnotes if their state standards and regulations differ from the text. After final review and editing the guideline is distributed in the distinctive DPC green cover to people worldwide. These guidelines represent the state of the knowledge at the time they are written.

Disclaimer

The DPC is not responsible for the use or application of the information provided in this Guideline. It is the responsibility of the user to ensure that the information addresses their needs and that any action taken complies with appropriate regulations and standards.

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INTRODUCTION

This guideline provides a practical discussion, for dairymen and certified equipment dealers, of the installation, cleaning, and sanitizing of small ruminant milking systems. The installation sections cover basic information regarding applications and approvals, the electrical power supply, the vacuum system and sanitary piping and components. The recommendations are kept in line with those of 3-A Accepted Practices for Design, Fabrication, American Society of Agricultural and Biological Engineers (ASABE) and Installation of Milking and Milk Handling Equipment, and with the Milking Machine Manufacturers Council of the Farm and Industrial Equipment Institute. Subjects discussed pertaining to cleaning and sanitizing include steps in cleaning mechanical cleaned pipeline systems, cleaning and sanitizing bucket milking machines, cleaning pulsation lines, cleaning farm milk tanks, and troubleshooting cleaning problems.

This revision was done to bring the standard in line with the ASABE standards ANSI/ASABE AD5707:2007 updated 2016 (for milking system construction and performance); ANSI/ASABE AD6690:2007 (Testing of milking systems); ANSI/ASABE AD3918:2007 (Terminology). ASABE has adopted the ISO standards for milking systems with deviations for changes needed to work in the US market. These are ANSI approved standards for the US. This guideline was developed to be useful in highlighting key elements basic to putting in place and operating milking systems to consistently yield high quality milk. It is not intended to be a definitive manual covering installation, cleaning, and sanitizing.

Related DPC Guidelines that may be helpful:
002 Effective Installation, Cleaning and Sanitizing of Milking Systems
004 Installation, Cleaning and Sanitizing of Large Parlor Milking Systems
059 Production and Regulation of Quality Dairy Goat Milk
071 Farmers Guide to Somatic Cell Counts in Sheep
072 Farmers Guide to Somatic Cell Counts in Goats
073 Layout of Dairy Milkhouses for Small Ruminant Operations

DEFINITIONS

Cistern – Cavity where the milk can collect between milking.

Tungsten Shielded Arc Method – Welding process that uses the arc between a non-consumable tungsten electrode and the weld pool with a shielding gas.

Stratified Flow – A multiphase-flow regime in which the fluids are separated into different layers, with lighter fluids flowing above heavier fluids

Proteinaceous – Having to do with or resembling protein.

GUIDELINE CONTENT

The popularity of goat and sheep milk and milk products is increasing in North America, yet little has been written in the way of recommendations for milking systems and milking system function. This Guideline assembles the best information available to help the small ruminant dairy producer and the equipment installers decide on the best milking system that will produce the high-quality products consumers demand, in an effective and efficient fashion.

Physical characteristics differ between cows, sheep and goats and these differences must be understood in order to interpret the research that has been done and apply it correctly. Some differences are obvious such as that sheep and goats have two teats and a cow has four, and the teats on sheep are smaller than those on cows or goats. Some are less obvious: goats, and many breeds of sheep, store more of their milk in the main cistern of the udder whereas cows store most of their milk in the milk producing areas of the udder. The location of sheep's teats, often being on the side rather than the bottom of their udder, present interesting challenges. Variations such as these will dictate different operating parameters in the milking system. The use of cast-off equipment designed for cow milking is not always the best, or even a good, solution. The use of modified equipment designed for cow milking should only be done after careful consideration.

Milk is an ideal medium for the growth of bacteria. In the early twentieth century, several outbreaks of human illness were caused by pathogens in milk. The production, pasteurization and other processing of milk and dairy products became a public health concern. Regulations, inspections, and enforcement of strict standards have effectively minimized pathogens in milk and dairy products, and ensured a safe, high quality milk supply during the latter half of the twentieth century throughout the United States.

Dairy operations are commercial enterprises. Careful planning needs to assure:

- Suitable potable water supply for sanitation as well as an ample supply for the animals.
- Plans for the disposal of waste from milk houses as it contains cleaning residues and milk waste (see Guidelines 15).
- Milkhouse and milking center plans including provision for adequate ventilation.
- Properly designed milking and milk cooling systems.
- Reliable electrical supply and back-up generator.

NOTE: All Chemicals should be stored in a secured area to prevent accidental mixing, skin contact or availability to children. "Child-proof" pump guards are strongly recommended.

Milking Machine Function

Basic to the operation of any milking machines is a partial vacuum or "negative" pressure between one-third and one-half of the atmosphere in a confined bucket or pipeline, through a tube and hose to a milking cluster. This pressure differential moves milk away from the animal's teats, or fluids away from any opening since air rushes in to equalize pressure. A continuous vacuum would stress the teats, so air is admitted between the shell and liner by the pulsator to collapse teat cup liners (inflations) and massage the teats. Milk should flow directly away from each teat preventing flooding or cross contamination among glands. Shaking or agitating milk leads to possible foaming and increased rancidity, so milk should flow gently through milk lines and not mix with air. Conversely, pulsing air and fluids are needed to create turbulent and fast-moving slugs of rinsing, washing, and sanitizing solutions to effectively clean milking systems.

There are two basic types of milking systems: 1) Bucket and 2) Pipeline. The bucket system uses a sanitary pail with a sealed lid to maintain vacuum. Vacuum is provided to the unit by hoses. The milking clusters are connected by a hose(s) to the pail where the milk is captured. The milk is transferred to a can or bulk tank for cooling and storage until the milk is picked up for processing. Pipeline systems have a milk line that concurrently carries milk and the milking vacuum. The milking cluster is connected to the pipeline where the milk flows to a receiver by gravity for transfer to the bulk tank for storage and cooling.

Pulsation rate is one of the differences between cows and small ruminants although, as with cows there are no exact standards. The teat cistern is smaller than in sheep and most goats than cows. Sheep teats are typically smaller than those on a goat. This means that the open phase of the pulsator does not need to be as long as with cattle for optimal milk flow. **Speeding up a pulsator that is designed to operate in the 45 -65 PPM range used by cattle, to the 60 to 180 PPM range, used by small ruminants, may not give you the desired effect as the opening and closing times may take too much of the cycle.** We will discuss more on pulsation when we get to the "Pulsation Speed and Ratio" section of the guideline.

Milk line size is another major difference as milk flow rates are much lower than that of cows. Goats may peak as high as 10 to 15 pounds of milk per day and sheep will peak around 5-7 pounds per day so it is obvious that the units per slope can be greater than with cows that peak between 60 and 100 pounds per day or more. The 10-20 pound per minute peak flow rate that we talk about with cows has little meaning to a sheep where the average milk-out is less than a minute. Goats typically milk in 2 to 6 minutes. Similarly, it is desirable to maintain stratified flow throughout a pipeline system where the line is simultaneously carrying milk from the animal and vacuum back to the milking cluster.

Vacuum levels are slightly lower than with cows, however, the principle of minimizing liner slippage is the same.

Applying for Installation Permit

An application to install new equipment or make changes in existing milking equipment must be submitted to the appropriate regulatory authority in the state where the farmer produces milk, and to the certified milk inspector, when needed. The application, including properly prepared plans, must be signed by the dairy farmer and/or equipment installer, and submitted ten (10) days before installation is begun. This includes any equipment in contact with milk such as milk transfer systems, pipeline milkers, in-line coolers, automatic takeoffs, stimulators, back flush systems, farm milk tanks and other components. Each state may have different application forms. Check with the local regulatory agency before installing or modifying any milking system.

Approval

Approval, disapproval, or conditional approval should be specific from the milk inspector and returned to the installer and/or dairy farmer within ten to thirty (10-30) working days depending upon the State requirements where it is applied for. Installation of milk handling equipment should not begin until approval is given.

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Testing and Training

The installer should train the farmer and test the milking system for proper operation and performance in the presence of the dairy farmer. Proper milking, gentle milk handling and thorough cleaning should be demonstrated to the farmer, dairy workers, and milk inspectors. A copy of the milking time analysis should be reviewed with the dairy farmer. Although little research has been done on stray voltage in sheep and goats a reasonable goal would be to keep the voltage between equipment and ground (neutral to earth) to less than 0.5 volt. Check with qualified personnel and refer DPC042, *Stray Voltage on Dairy Farms*. New installations are required by the National Electrical Code to install an equipotential plane in any area where the livestock and touch something that may become energized. For more information see the

National Electrical Code Section 547-10 on equipotential planes and bonding in agricultural buildings also refer to ASABE EP473.2 on equipotential planes.

Operating Instructions

Operating instructions and maintenance schedules from the manufacturer, dealer and installer must be provided. These include daily assembly and disassembly procedures; lubrication or replacement schedules; and routine maintenance for liners, pulsators, vacuum controllers, vacuum pumps, milk pumps, etc. If a dairy farmer suspects any malfunction, notify a qualified dealer or consultant promptly to prevent more costly breakdowns.

Electrical Power Supply

Check with Power Supplier

Before changing electrical wiring, or adding electrical equipment, contact your power supplier to see if power lines or transformers are adequate for the increased load. They also may suggest improvements that can save time, money, and electric power.

Conform with Codes

The electrical system should conform to the National Electric Code and other local regulations and codes. The power company lines, and service entrance wire size should be large enough to carry the maximum current without overheating. Proper grounding helps prevent minor and major accidents.

Protect Yourself

Bonding

The milking system should be bonded to metal stalls, concrete reinforcing, and the electrical system ground. When bonding stainless steel, use stainless steel or compatible connectors to minimize corrosion due to electrolysis. See The National Electric Code, ASABE EP473.2 on equipotential planes and DPC042, *Stray Voltage on Dairy Farms.*

Ground Fault Interrupters

Ground Fault Interrupters (GFI's) save lives and should be installed in damp locations as recommended by the National Electric Code. All wiring in wet locations must be water resistant. Electrical cords should be resistant to moisture, oil, and fats **(NEC** Table 400-4), and connected with waterproof connectors.

Protect Your Milk

Milk Line Position Switch

Each milking pipeline should have a milk line position switch installed on the milk discharge line that swings between the farm bulk tank and the wash vat. This can prevent wash water from accidentally going into the farm milk tank during the wash cycle and can prevent accidental discharge of milk into the wash sink during milking.

The Vacuum System

Vacuum Pump

Location

Locate the vacuum pump close to the milking center in a clean, dry, well-ventilated space. The vacuum pump and other necessary power units should be in a room large enough for regular maintenance and separate from the milk room or milking barn to minimize problems from both oil and noise.

Types

Types of pumps available include the most common sliding-vane rotary pumps, water-ring pumps, rotary lobe, and turbine pumps. Pumps can be damaged by small amounts of water or cleaning solutions. Piston pumps are no longer used for modern milking systems; however, old ones are still in use on some bucket systems. Most of them do not produce adequate vacuum to maintain a stable supply and pumps of less than 2 horsepower should not be used.

Size

The vacuum pump needs to large enough that the working vacuum does not vary more than ± .6 inches of mercury (2 kPa) under normal milking operation, including teat cup attachment and removal, liner slip or teat cup/cluster fall. The following table contains recommendations based on ANSI/ASABE5707 2007 updated in 2016 Informative Appendix D Table D1. Use the formula in the appropriate cell to calculate the minimum effect reserve needed. The standard is that you should be able to invert one unit (with any automatic shut-off disabled) and not lose more than 0.6 inches of mercury (2 kPa) with all of the units pulsating and ready to milk. For systems with more than 32 units you should be able to invert 2 units (per 5.2.4.4 ANSI/ASABE6690 2007 updated in 2016. For non-conventional clusters refer to ANSI/ASABE5707 2007 updated in 2016.

Table 1. Recommended Minimum Air Flow Requirements to Milk

Number of Units = n	**Minimum Effective Reserve[a]**			
	Pipeline		**Buckets**	
	CFM free air	**l/min free air**	**CFM free air**	**l/min free air**
	Conventional Cluster without automatic shut-off valve			
n ≤ 10	7+(0.7*n) + 14 per operator	200 + (20*n) + 400 per operator	3.5+ (0.7*n)+ 7 per operator	100 + (20*n) + 200per operator
n > 10	14+0.35*(n-10) + 14 per operator	400 + 10*(n-10) 400 per operator	10.6+0.35*(n-10) + 7 per operator	300+10*(n-10)+ 200 per operator

a – Add the airflow required for any ancillary equipment such as vacuum dumping station, doors, etc.

NOTE: Washing Vacuum Air Flow Requirements: Airflow required during washing may be different than that required for milking, if air and liquid flowrates are well controlled it may be less. Calculate the vacuum pump capacity required for cleaning by multiplying the number of units times 2 cfm (60 l/min) and adding the air injector use from Table 3 for each milk line loop. The total should be no less than Table 2.

Table 2. Minimum Air Flow to Wash*

Line Size	CFM (ASME)	LPM
1.5” 36mm	25	700
2” 48mm	40	1120
2.5 60mm	60	1680

* per loop of pipeline each additional loop will need approximately 50% addition airflow

Table 3. Typical Air Injector Air Flow Needs

Nominal line size	cfm per loop*	Liters/min. per loop*
2" (48 mm)	17	480
2 1/2" (60 mm)	24	680
3" (73 mm)	33	930
* For multiple loop systems, multiply the number of loops times the air injector requirement, unless the air injectors are sequenced		

NOTE: Increasing the airflow available with upgrades to the vacuum system will change wash dynamics. You may need to adjust or modify your air-injection system to better control wash flow; a larger milk pump to handle increased wash flow; or both.

Adjustment for Elevation

Adjustment for elevation needs to be made for farms located over 1000 feet (305 meters) above sea level. The adjustment factor is about 3% per 1000 feet (305 meters). Check with the manufacturer of your vacuum pump for exact adjustments.

Exhaust

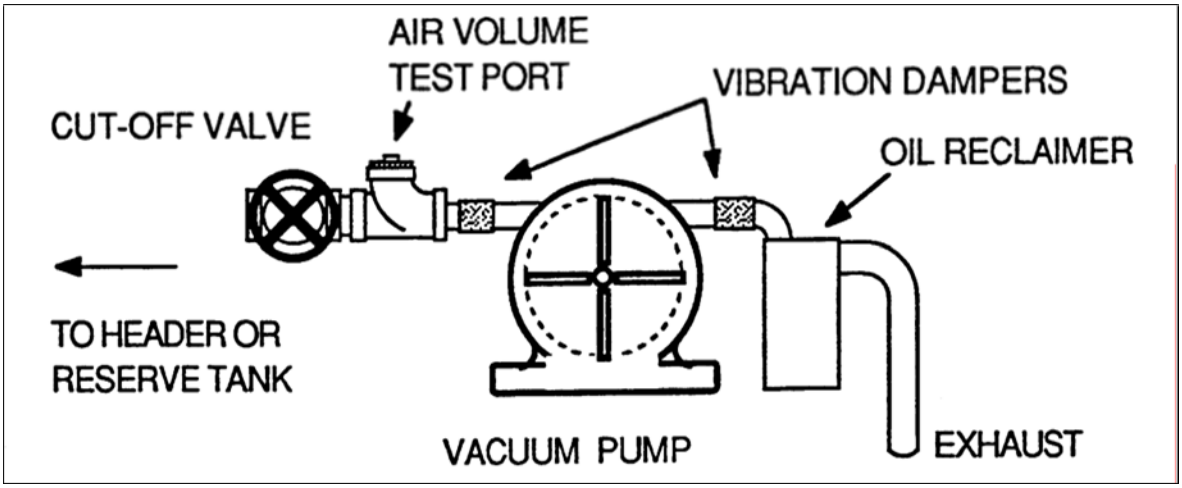
Pump exhaust pipes should meet the manufacturer's recommendations. The exhaust port on oil-lubricated pumps should go directly outside the building using a minimum of fittings. Do not exhaust near the refrigeration condenser unit, or into the barn, parlor, milkhouse, or feed room. The exhaust should be directed downward and away from any openings in the building. Pumps other than oil-lubricated may be exhausted differently. Follow manufacturer's recommendations.

Caution: Exhaust gases can be very hot and may contain oil. Risk of fire exists if not properly installed

Rotary sliding-vane pumps use oil lubrication. Oil reclaimers should be installed to conserve oil and to reduce soil contamination from the oil-laden exhaust air. **To prevent possible damage if the pump reverses rotation during shut down, install one-way check valves to limit reverse rotation. This also minimizes the risk of contaminating the vacuum system with oil.**

Connections to vacuum pumps should include vibration dampers to isolate noise, vibrations, and fatigue in steel or plastic pipe. Careful cleaning, priming, and gluing is needed for joining rigid polyvinyl chloride (PVC) pipe. An air volume test port with fittings and a full flow cut-off valve should be installed so the airflow from the vacuum pump can be tested (See Figure 1).

Figure 1. Vacuum Pump



Regulators & Safety Valves

Capacity

The capacity of regulators (vacuum controllers) should equal the full capacity of the vacuum pumps at the operating vacuum. Normal loading of the system should not reduce the operating vacuum level more than 0.6 inches of mercury (2 kilopascals (kPa)). Overshooting the vacuum set point after a major air influx should not exceed 0.25 inches (1 kPa).

Location

Locate regulators to receive clean air and be easily accessible for cleaning, especially the operating valve. Filters protect the regulators but must be serviced regularly. Install regulators according to the manufacturer's recommendations on the main supply line at or near the distribution tanks, or close to the sanitary trap, but not on sanitary piping (milk lines) or pulsator lines. With bucket systems, install the regulator between the pump and first vacuum tap (stall cock).

Safety Release Valves

Safety release valves allow air to enter the vacuum system in case of regulator failure. This prevents possible pump, tank, line damage or animal trauma. Safety relief valves are designed to protect the system from increasing vacuum level beyond a safe operating level.

Vacuum Level

The vacuum level best for your system will vary depending on cluster weight, liner characteristics and pulsation. Follow the manufacturer's recommendations or consider operating vacuum levels as listed below. Remember that claw vacuum is difficult to accurately measure.

Table 4. Vacuum Levels for Goats

System	Mercury	kPa
High line	13 to 14	44 to 48
Low line	11 to 12.5	38 to 42
Mid line	12 to 13.5	41 to 46

Recommended claw vacuum at peak flow of 10 to 12 inches of mercury or 35 to 41 kPa.

Table 5. Vacuum Levels for Sheep

System	Mercury	kPa
High line	12.5 to 13.5	42 to 46
Low line	10.5 to 12	36 to 41
Mid line	11.5 to 13	39 to 44

Recommended claw vacuum at peak flow of 9.5 to 11.5 inches of mercury or 32.5 to 39 kPa.

Air Lines (Vacuum)

Materials

Materials for air (vacuum) lines should withstand vacuum levels of 25 inches of mercury (85 kPa) as well as cleaning fluids. Rigid plastic pipe (Schedule 40 or heavier) is common and proper supports should prevent any sagging.

Size

Main Vacuum Line Sizing

The main vacuum line, line between the vacuum pump and the distribution tank, should be a maximum of 100 feet (30 M) long with a minimum diameter of 2 inches (2" or 48mm ID on systems up to 50 CFM (ASME) (1400 LPM). On systems at 50CFM (1400 LPM) with main vacuum lines less than 60 feet (9 M) long may also use 2-inch (2" or 48mm ID) lines. On systems 50 to 125 CFM (ASME) (1400 to 3500 LPM) a 3-inch (3" or 73 mm ID) line is recommended. For systems over 150 CFM (ASME) contact the manufacturer of the equipment.

Trap Line

The size of the trap line is dependent on the location of the vacuum regulator. If the vacuum regulator is on the trap line the size will be the same as that of the main vacuum line. If the pulsator is not on the trap line, then the trap line only needs to be large enough to carry the recommended effective reserve airflow. For effective reserve vacuum of up to 50 CFM (ASME) (1400 LPM) a two-inch (2" or 48mm ID) line is recommended. On systems at 50CFM (ASME) (1400 LPM) with trap lines less than 60 feet (9m) long may also use two-inch (2" or 48mm ID) lines. On systems over 50 to 125 CFM (ASME) (1400 to 3500 LPM) a three-inch (3" or 73 mm ID) line is recommended. For systems over 150 CFM (ASME) contact the manufacturer of the equipment.

Pulsation Lines

Pulsation lines should be two-inch diameter (2" or 48mm ID) and three-inch diameter (3" or 73mm ID) lines are recommended with more than 36 milking units. Install vacuum taps (stall cocks) in the top half of the air or pulsation lines for complete drainage. A looped configuration is preferred, if a single feed line is used, the header should be one size larger than the pulsator line recommendation

Pulsation Speed and Ratio

Most research indicates that higher rates than those used by cows are acceptable to small ruminants. A myth persists that a machine should mimic a newborn nursing. This assumption needs further study because a milking machine is designed to extract the milk in a relatively short period of time. Although a lamb may suckle at a rate of 120 or more times a minute a lactating animal will generally let down at other rates. Pulsation speed is defined as pulsations per minute (PPM)

Installation

Install pulsation lines with a continuous slope at 1/2" per 10 feet (0.4%) or more toward the distribution tank, and in the direction of airflow from milking units. Install lines as straight as practical and rigidly support to prevent sagging. Stall cocks on systems where the pulsators are removed each milking should have additional reinforcement or use a clamp-on type. Minimize the number of fittings and elbows but use sweep T's and full flow valves to facilitate cleaning, inspection, and testing. (See Figures 6 and 6a for typical examples)

Drains

Install automatic drain valves and clean-out T's at all low points and at the ends of long runs of pipe, such as a pulsator line.

Table 6. Generally Recognized Acceptable Speeds and Ratios

	Acceptable Speed	**Typical Speed and Ratio**	**Acceptable Ratio**
Goats	60 - 120 PPM	85 PPM 60% milk	50 - 70 % Milk
Sheep	90 - 180 PPM	120 PPM 50% milk	50 - 70 % Milk

CAUTION: Pulsation design and the opening and closing speeds affect, effective milk, and rest times. Speeding up a cow pulsator, may or may not give adequate milk and rest times. Care needs to be taken to assure adequate rest phases so that damage to teat ends does not occur.

Sanitary Traps

Sanitary traps connect and separate milk lines and air (vacuum) lines. They have a vacuum shut-off if the trap is filled with liquids from the milk line and are self-draining. The sanitary trap is located 12" (30 cm) or less above the milk receiver, and the receiver-trap connection should be readily dismountable, with sanitary piping sloping toward the trap.

Sanitary Piping and Components

Milk and Wash Lines

Fabrication

All milk contact surfaces shall have a finish at least as smooth as No. 4 mill finish on stainless steel sheets and be free of imperfections such as pits, folds, and crevices in the final fabricated form. All milk contact surfaces must comply with 3-A, No. 606--.

All milk handling lines should meet "3-A Sanitary Standards for Multiple-Use Rubber and Rubber-Like Materials used as Product Contact Surfaces in Dairy Equipment, No. 18-03" and "3-A Sanitary Standards for Multiple-Use Plastic Materials Used as Product Contact Surfaces for Dairy Equipment, No. 20-27". PVC is not acceptable in either milk or wash lines.

Welding

Welding stainless steel pipelines by careful, skillful welders using the Tungsten Shielded Arc method can produce smooth joints with no pits. Inspection of welds with a boroscope may be required. To check performance, have the welder set aside the first weld each day for inspection**. The regulating authority should be notified before installing a welded system**.

Inspection Ports

Two inspection ports or removable elbows are recommended for each loop of a pipeline, one near the high point and one on the return wash line. Additional inspection ports may be needed in lines with unusual configurations.

Ferrules & Gaskets

Effective January 1, 2001 all ferrules must be welded on. Rolled ferrules will no longer be acceptable. Ferrules & gaskets are needed to disconnect elbows, sweeps and other fittings or components. For rolled ferrules, pipe should be cut using a saw guide or cut-off saw and rolled flush to the ferrule with the edge smoothed using a facing tool. Gaskets should be installed flush with the interior of piping, properly seated and not over tightened. Inspect gaskets periodically and replace when air leaks or deterioration occurs. Because they are resistant to stretching and decomposition, Teflon gaskets should be used for elbows that need to be turned as on a swing line.

Support

All milk lines should be rigidly supported to maintain a continuous slope of at least 0.8% (1" per 10 lineal feet) as specified by regulatory requirements.

Support hangers should be:

- Fully adjustable vertically yet able to flex for thermal expansion and contraction of milk lines
- Insulated or similar metals to prevent electrolysis between dissimilar materials
- Located close to each milk inlet to limit line deflection during use
- Less than 10 feet apart
- Attached to secure base to avoid sags in line (Not to ceiling of stable with overhead storage)

Sleeves

Sleeves should be installed wherever sanitary piping passes through walls, solid partitions, etc. Use sleeves large enough to easily remove pipes and do not put connections within sleeves. Block the space between the milk line and the sleeve to prevent the entrance of dust or flies or other insects into the milkhouse.

Insulation

Insulating around-the-barn pipeline and/or wash tanks may be necessary if the wash solution temperature cannot be properly maintained. Use closed cell insulation approved by the local regulatory agency, and do not cover inlets or couplings.

Figure 2. Vacuum Line and Vacuum System Layout

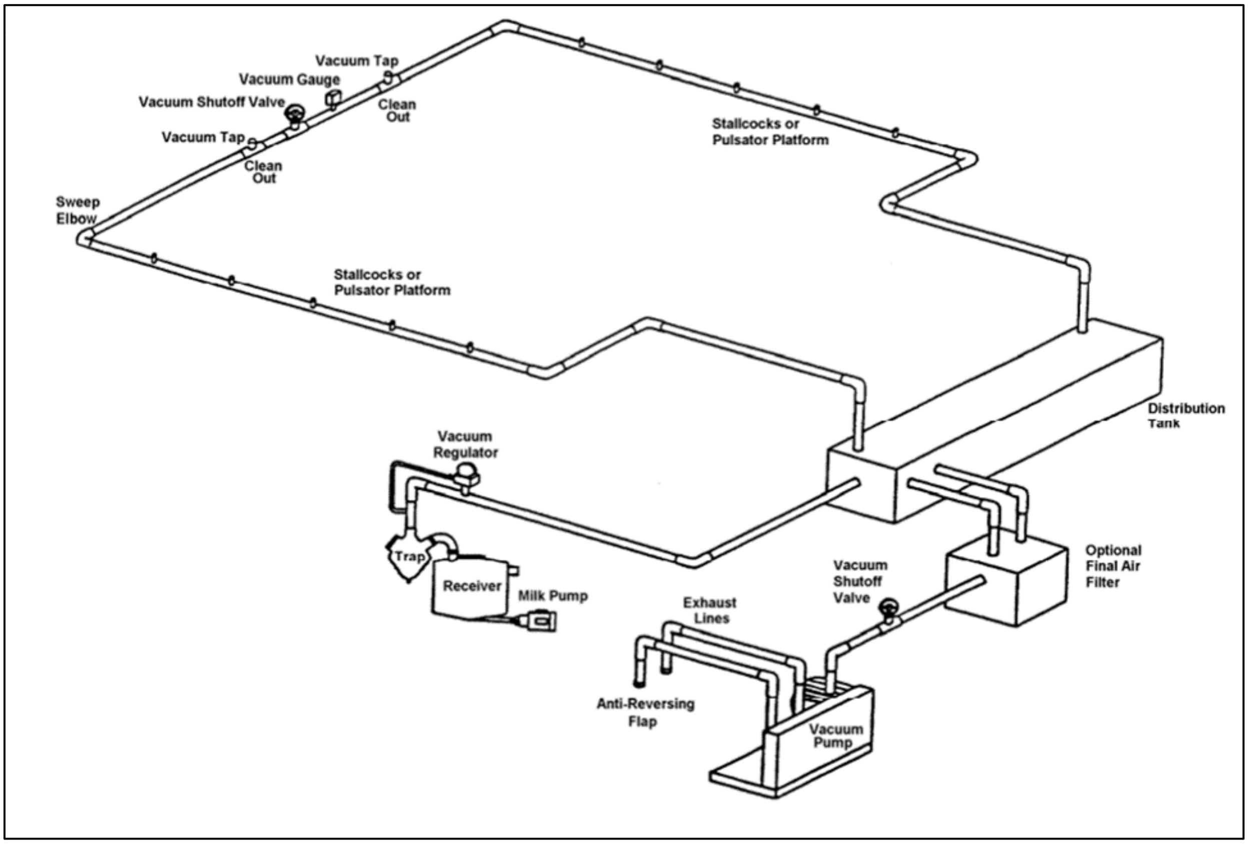
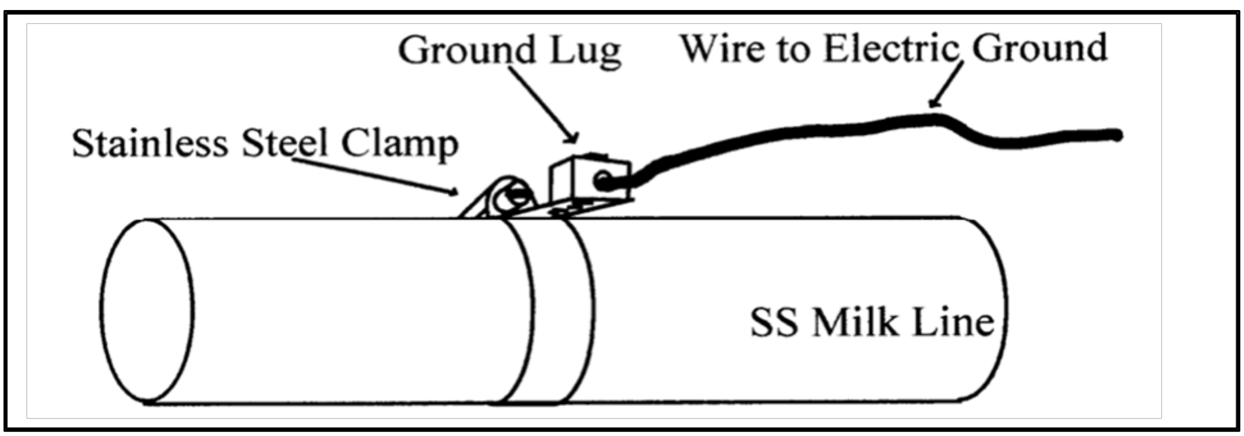


Figure 3. Example of Bonding



Grounding and Bonding

Grounding or bonding to the electrical system ground of the stainless-steel milk lines, and all exposed metal that may become energized, is required in the **National Electric Code**. Copper and aluminum conductors should not make direct contact with stainless steel milk lines because electro galvanic corrosion may occur. (See Figure 3)

From Milking Clusters to Receiver

Milking Cluster

The milking cluster is the assembly of the liners, shells and other parts needed to remove the milk from the animals and allow it to flow to the pail or pipeline. Two general types are used. Both types require air vents to facilitate milk movement away from the animals and minimize flooding in the liner.

The traditional system uses a claw as a gathering vessel between the liners and the milk hose carrying the milk to the pipeline or pail. In this type of system, the claw needs to be large enough to minimize flooding (filling of the claw with milk) as flooding may increase the chance of mastitis pathogens entering the mammary during milking.
NOTE: Claws that were too small for cows may be too small for sheep or goats as well. Use a claw that is designed for use with the species being milked.

With claw systems the air vent can be either in the short milk tube between the base of the liner and the claw, or in the claw.

The second type involves milking with no claw. The short milk tubes from the liners are extended all the way to the milk line or pail, or there is a fork placed in the milk line to combine the milk flow from each liner. Either of these require an air vent in the milk tube close to the end of the liner. If a fork or wye is placed in the milk line be sure it has enough capacity to move the milk and is constructed of approved materials. The extended milk tube between the fork and the liner should be approximately 3 to 4 feet (1 meter) long to minimize the risk of cross-half contamination.

Air Inlets

Air inlets in the milking unit (teat cup and claw assembly) should be as small as needed to move milk.

Liners

Liners on systems operating at greater than 60 PPM may need to be changed more frequently. The number of washings compared to milking will also affect the frequency of liner changes.   If any change in the milk ability of the system is noted when liners are changed, the liners probably need to be changed more often. Check with the manufacturer for more information.

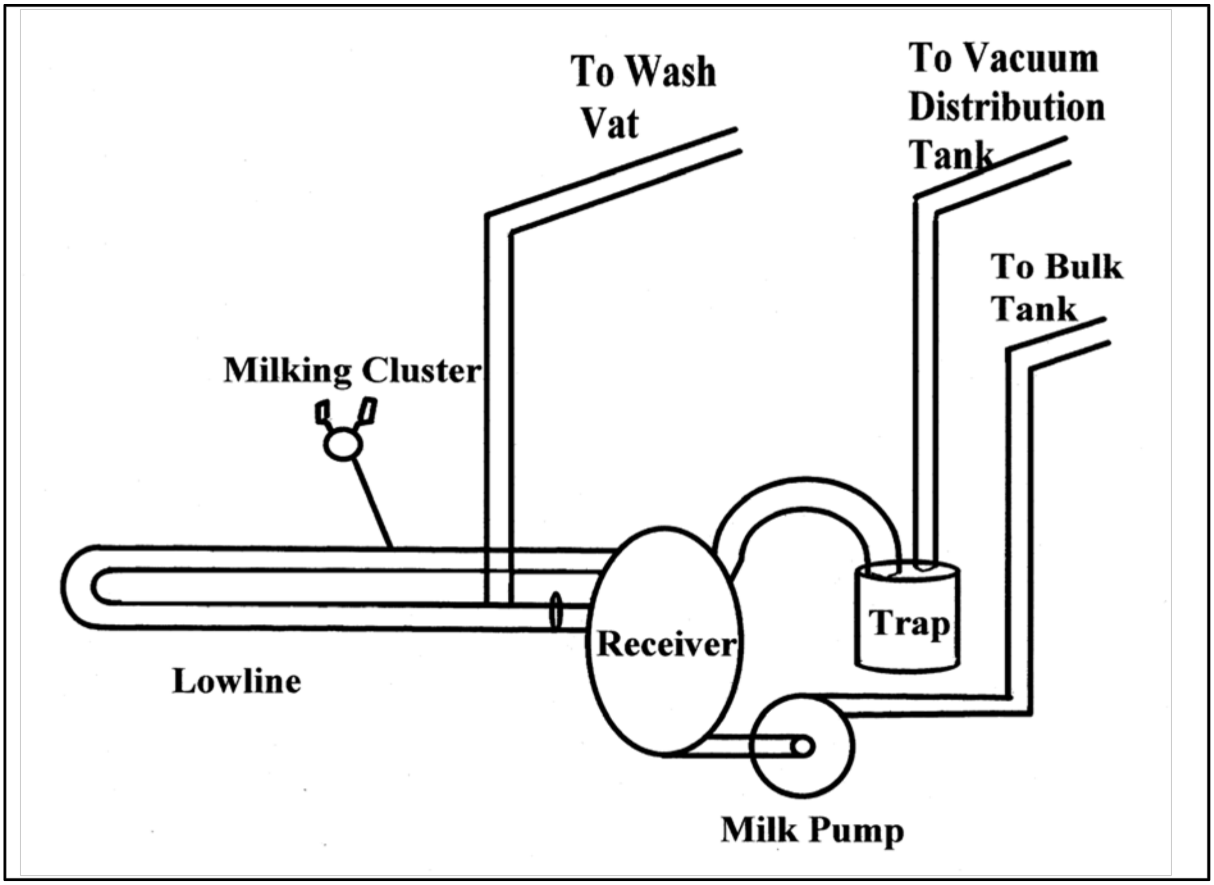
Milk Hoses

Milk hoses between the milking unit and milk line should be as short as practical to reduce vacuum differential between lines and units and should not exceed 9'.

Milk Inlets

Milk inlets and inlet valves should be airtight, self-draining, designed for CIP cleaning and installed so that milk enters the top half of the milk line. Deburr and polish holes and align inlets perpendicular to holes. Properly installed welded inlets may reduce air leakage.

Figure 4. Low Line Pipeline System for Milking Parlors



Milking Pipelines

Milking pipelines should be large enough to carry both milk and air from milking units without flooding lines or causing excessive turbulence. Milking pipelines should be looped to the vacuum source when milking; be the same diameter for any loop; and not include any risers. Low lines are used more in milking parlors and generally provide gentler milk flow and more stable milking vacuum, but high lines are isolated from animal damage.

Multiple Loops

Multiple loop pipelines should have separate air injectors for each loop and be of similar length for consistent washing. They may use common piping to feed rinse/wash solutions through splitter T or Y fittings to the different loops. Recombining wash solutions before entering the receiver should be avoided, and both wash and milk flow is improved with multiple inlet receivers.

Lowlines should be a horizontal loop with a wash valve next to the receiver inlet.

Units per slope

To maintain stratified flow in a pipeline milking system there are several factors that need to be considered. The primary ones are milk flow rate, air flow from the air bleeds on the milking cluster, cluster type, air flow from unit attachment, how fast the units are attached, the peak flow rate of the animals being milked and the duration of milk let down. Table 3 uses the assumptions noted below. If an installer wishes to vary one of the assumptions, they should refer to ANSI/ASABE5707 2007: Update 2016 for the formula or Table needed to calculate the proper number of units per slope. The assumptions in the chart are for the highest anticipated flow and attachment rates with conventional milking cluster. Attachment rates significantly affect the calculations. If multiple operators are attaching simultaneously less units per slope should be recommended. In the US, the preferred slopes are 1.0% to 1.2%.

Assumptions:

- Attachment rate of 5 seconds per unit
- Goats and some sheep will typically take longer than 2 minutes to milk
- Sheep typically take less than 2 minutes to milk
- Operators careful to admit very little air during attachment.
- Low flow is 1.8 lbs./min (0.8 kg/min)
- High flow is 2.9 lbs./min (1.3 kg/min)

Table 7. Guidelines to Assure Stratified Flow in Looped Milk lines
Recommended Number of Units Per Slope
Inches of Slope in 10 Ft.

Nominal Line Size		**1.0" (0.8%)**		**1.2"(1.0%)**		**1.75"(1.5%)**	
Milking duration		< 2 minutes	> 2 minutes	< 2 minutes	> 2 minutes	< 2 minutes	> 2 minutes
1.5" (36mm) mm	Low Flow Breeds	3	3	3	3	5	5
1.5" (36mm)	High Flow Breeds	2	2	2	2	3	2
2" (48mm)	Low Flow Breeds	9	8	11	10	a	13
2" (48mm)	High Flow Breeds	6	5	9	6	a	8
2.5" (60mm)	Low Flow Breeds	a	18	a	22	a	a
2.5" (60mm)	High Flow Breeds	9	12	a	16	a	22
3" (73mm)	Low Flow Breeds	a	a	a	a	a	a
3" (73mm)	High Flow Breeds	a	34	a	a	a	a

a – With the attachment rate stated there is no limit to the number of units per slope as animals will be done milking as more are attached. Multiple operators would need a larger line.

From Receiver to the Milk Tank

Receiver Group

The receiver group includes a container where milk is released from vacuum by a pump. The milk receiver group should be located in the milk room, milking parlor or area meeting milk room specifications for floors, walls, ceilings, lighting, and drainage. The receiver is constructed of an approved material and all milk contact surfaces should be easily inspected or transparent. It is also a receiver for washing solutions, which are pumped to the wash tank or vat while preventing the sanitary trap from flooding.

Milk Pump

The milk pump is at the lowest point in the system and must have an automatic drain. The pump motor should be totally enclosed with water-proof electrical connections, proper grounding, and ground fault interruption device. **The milk pump must be sized to accommodate the washing and milking equipment on the system, i.e. precoolers and filters.** There should be a disconnect to allow for easy pump replacement.

Probes

Probes to start and stop the milk pump shall be cleanable by recirculation and removable without disconnecting milk lines. Provide sufficient clearance and long enough electric cords to easily remove the probes. Locate so milk does not rise to the level of inlets.

Milk Filters

Milk filters promptly remove extraneous sediment from milk and indicate cleanliness of milk to the producer. Based upon the maximum flow rate and the number of animals milked, the certified dealer should recommend the proper size filter and its limitations in performance. Clean housing, clean animals and proper cleaning of the animal's teats helps produce clean milk.

Milk filters should be non-toxic, non-shedding, insoluble and not impart a flavor to the product. Cotton, linen, or synthetic materials may be used for single service filter media. (Ref: "**3-A Sanitary Standards for Milk and Milk Products, Filters Using Single Service Filter Media", Number 10-03 para. C1.3)**
Milk should be filtered before entering a plate or tube cooler where sediment could collect and adversely
affect milk and wash solution flow. On systems with an in-line cooler a new filter should be installed prior to washing to prevent the deposit of foreign materials in in-line coolers during the wash cycle. If significantly soiled, it should be again replaced prior to sanitizing.

Three Types of Filters

- In-line Pressure filters – most common in modern milking systems, located on the discharge side of a releaser pump, and not likely to interfere with milking vacuum.
- Gravity Filters – most effective in retaining sediment, if of good filter material, properly supported and installed to prevent by-pass of milk. These are most common in bucket systems.
- In-Line Unit Filters under Vacuum – can be used if it is demonstrated that milking vacuum is not affected (i.e., filters on the discharge side of weigh jars).

Precoolers

In-line precoolers are optional heat exchangers, which partially cool milk. Plate or tube coolers can be located in the parlor or in the milk room. Precoolers and all associated piping needs to drain completely after each wash cycle.

Discharge Line

The discharge line into the farm milk tank should minimize foaming and discharge milk as close to the bottom of the tank as practical. Lines discharging milk into a tank should end with a polished angle cut (approximately 45 degrees) and have a weep hole below the lid and above the milk level to prevent siphoning. All lines carrying precooled milk entering through but not permanently attached to the top of the receiving vessel should have a sanitary drip shield that overlaps the edges of the opening in, or close to, the cover. 3-A Standards now require drip shields on all drop pipes.

Bottom loading is permitted. The connection to the tank should have a check valve to prevent accidental milk loss. Plug type valves that hold milk in the plug, are not accessible for cleaning and are not acceptable for a bottom fill tank.

Sliding a hose over a sanitary pipe is not an acceptable CIP cleaning connection.

Milk Line Position Switch

A milk line position switch for the "swing line" of the milk discharge pipe can prevent wash water from accidentally going into the farm milk tank during the wash cycle, and also prevents accidental discharge of milk into the wash sink during milking.

Washing Components

Wash Valve

Wash valves allow the single direction flow for cleaning pipelines. The wash valve is designed to pass solutions to the wash inlet of the receiver and to allow piping to drain. Wash valves should be located close to the receiver and allow sufficient solution to thoroughly clean between the valve and first inlet.

Wash/Mechanical Cleaned Lines

Wash/mechanical cleaned lines, if under vacuum while milking, must be disconnected to make an atmospheric break and capped above the flood rim of the sink during milking. Shut-off valves do not provide sufficient protection. Wash lines and valves must be sized to the system by a certified dealer according to manufacturer's recommendations.

Wash Tanks or Vats

Wash tanks or vats hold the solutions for rinsing, washing, and sanitizing operations and are sized to hold the greatest amount of solution needed for one cycle. If the fill time is longer than five minutes or more than 50 gallons are needed per cycle, an enclosed sink or vertical tank with removable cover or access port is recommended. Vertical wash tanks take up less floor and wall space than vats, and with less exposed liquid surface area, have less heat loss and higher temperatures for return solutions. They should have removable covers for cleaning and inspecting.

Diversion Valves

Diversion valves or automatic diverters should be installed to discharge and prevent recirculation of the first rinse.

Wash Inlets

Wash inlets should be designed so that milk contact surfaces are effectively cleaned during mechanical cleaning.

Wash Manifolds

Wash manifolds with wash inlets for around-the-barn pipeline milking systems shall be a sanitary line remote from and the same size as the milk line. (See Figure 5). The Line to the wash manifold must be higher than the milk line.

Wash manifolds (jetters) in milking parlors are used for CIP cleaning of individual milking clusters. Jetter cups must be covered while milking.

Air Injectors

Purpose: Air injectors are utilized to maintain the wash solution slug throughout the system. The slug of solution must return with enough force to wash the receiver and probes. There should be enough solution carry-over to wash the trap without flooding.

Wash Solution Volume Control: Wash solution volume must be controlled to prevent solution overflow to the trap shutting down the system. On around-the-barn pipelines, it is generally best to adjust the air injector on time to control wash solution volume. Restrictors in the wash solution draw lines are not recommended because the restrictors may slow slug movement and increase wash solution cooling. In milking parlors, restrictors in wash solution draw lines may be used to balance solution uptake to the capacity of receiver group, but it is better to restrict the flow at each unit washer than to restrict the entire system except for the line feeding the lowline loop. Air injector timing should be set to assure long enough wash solution slugs to adequately wash all units. In large parlors, washing sequencing or pump assisted washing may be required. These systems should be carefully designed and checked on a case-by-case basis.

Operation: The wash solution is accumulated next to the divert valve until the full diameter of the pipe is reached, for the desired length of slug to be formed. Air is suddenly admitted to the system to form a slug or plug flow condition. The slug of solution must traverse the entire circuit being cleaned without losing contact with all surfaces of the pipe. This means that air admission from the air injector must continue until the slug nearly returns to the receiver. Premature closing of the air injector will cause the slug to lose velocity and break from a plug flow condition. Cleaning failures can occur admitting air at too high a frequency, admitting air for too short a period of time, not admitting a high enough volume of air, or admitting too much air. Large diameter pipelines require precision adjustment of the air injection system.

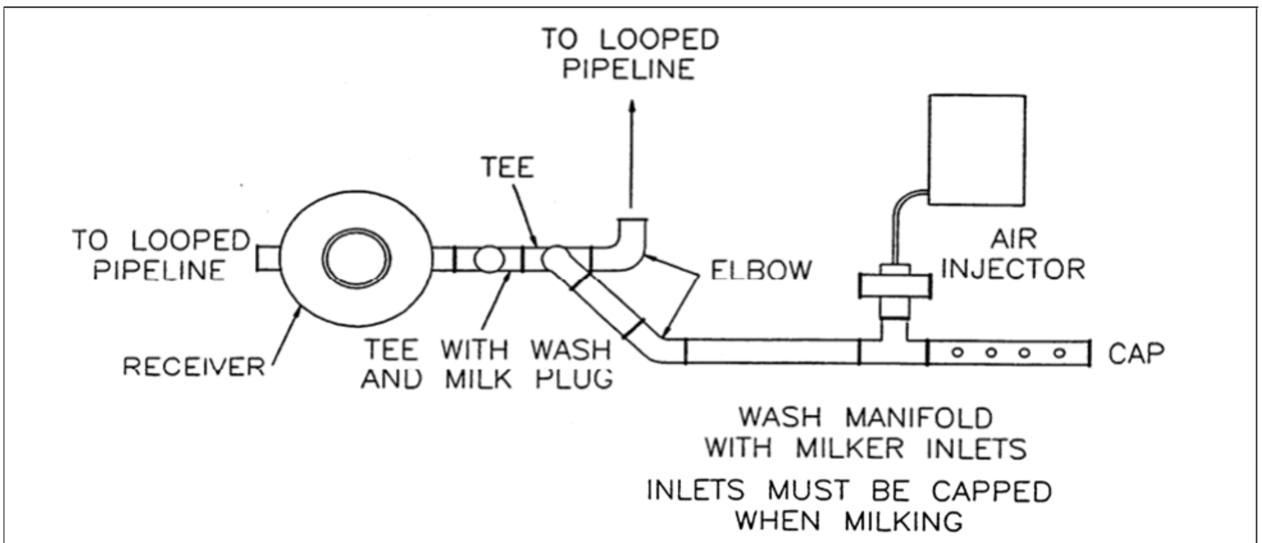
Location: Air injectors should be located where they can be kept clean and easily accessible. To assure a source of clean air, air injectors should be located inside the milk room. Generally, the air injector should admit air to the main circuit of the milk pipe. Air admission to the system should be as close as possible to the diversion valve. Air admission is often combined with a wash feed line to the main milk pipe. A separate air injector may service unit wash lines. Multiple air injectors frequently need to operate in synchronization.

Adjustability: Air injector valves need to be adjustable for volume, frequency and time duration of air admitted to the wash line. Air bleeds or constant frequency injectors are satisfactory only on small diameter pipes, i.e., 1 1/2 inches (36mm), or small systems. Likewise, air injectors using milk hoses for air admission, i.e. 9/16 and 5/8 inches, are limited to pipelines of 2 inches (48mm) or less in diameter and should be located less than 2 feet away from the wash pipe.

Mixing Components: Care must be taken when mixing components of systems from different manufacturers. Incompatible components may affect the milking and washing performance of the system. The last installer modifying a milking system should be responsible for the performance of the system and the interrelationship of other components already in service.

- Splitter Tees: All tees where wash solution converges or diverges should be "tee-wye" or "splitter tee" fittings.
- Lowlines: A lowline is the recommended system in parlor-type milking centers. Lowlines should be a horizontal loop with a wash diversion valve located as close as possible to the receiver jar. A sufficient amount of wash solution should enter the lowline adjacent to the wash valve to wash the lowline from the valve to the first milk inlet. The wash diversion valve should be constructed to allow enough wash solution bypass to wash the inlet of the receiver and to allow the piping to drain.

Figure 5: Wash Manifold



- Wash Manifolds: When using a milk room wall-mounted unit wash manifold, there should be minimal restriction between the milking cluster and the sink, i.e. 2 milk hoses feeding a 6-unit wash manifold. Air injectors should attach to the main wash circuit not the wash manifold.
- Hoses: Table 8 shows the minimum number of standard milking unit hoses drawing wash solution into a pipeline.
- Drainage: Hoses and piping should be self-draining.

- Volume of Wash Solution: Satisfactory cleaning of a pipeline milking system requires that an adequate amount of water be available for cleaning. To estimate the amount of water for each wash cycle, see tables 5 and 6. The water volume should be 30-50% of the internal capacity of the piping and receiver group; 100% of the discharge pipe and a 10% allowance for maintaining water in the sink and accessories.

Table 8. Minimum Number of Milk Hoses Feeding a Wash Line

Pipe Diameter	Draw hoses per loop
1.50" 36 mm	2
2.00" 48 mm	3
2.50" 60 mm	5

Table 9. Pipe Lengths to Contain 1 Gallon, Full Flooded

Pipe Size	Material	Length	
		Feet	Meters
36 mm 1-1/2"	S/S tubing	13	3.7
36 mm 1-1/2"	glass	11	3.2
48 mm 2"	S/S tubing	7	2.0
48 mm 2"	glass	6	1.7
60 mm 2-1/2"	S/S tubing	5	1.4

Table 10. Typical Capacity of Accessories

ITEM	CAPACITY	
	Gallons	Liters
Sanitary Trap	2.0 to 4.0	7.5 to 15
Receiver	7.0 to 20	26 to 76
Milk Meters	0.5 to 1.0	2 to 4
Plate Coolers	1.0 to 3.0	4 to 12
Weigh Jars*	3.0 to 10	11 to 38

*The usual allowance for washing is for 60+ pound jars, on small ruminant jars 1gallon may be sufficient. See manufacturers specifications for exact capacities

Table 11. Example calculations for Double 6 Parlor, 12 Units

Item			Gallons of Wash Solution Required	Liters
Weigh jars (12)			6.0	22.8
Pipeline, 80 feet, 2"				
80' @ 7'/gal = 11.4 gal	11.4/2 {50%}	=	5.7	21.7
Receiver, 15 gal	15/2 {50%}	=	7.5	28.5
Trap, 3 gal	3/2 {50%}	=	1.5	5.7
Discharge pipe, 50 feet, 1-1/2"				
50' @ 13'/gal = 3.9 gal	3.9 {100%}	=	4.0	15.2
Wash pipe, 100 feet, 1.5"				

100' @ 13'/gal=7.7 gal	7.7/2 {50%}	=	3.9	14.8
	Sub total		28.6	108.7
	Add 10% (sink)		2.9	11
	Total		31.5	119.7

Thus, the suggested sink size is 35 gallons or 135 Liters. The installer will need to adjust for each individual system.

Weight & Volume of Water at 60°F (16°C)

1 cu ft = 64.2 lbs. = 7.48 US gal = 6.23 Imp gal = 28 liters

1 US gal = 8.34 lbs. = 0.134 cu ft = 0.833 Imp gal = 3.785 liters

Booster Heaters

Electric booster heaters are energy intensive and dangerous. On long pipelines or large parlors where maintaining wash solution temperatures are a problem, an in-line precooler can be used as a booster heater. A circulator pump to a hot water heater that has sufficient thermal mass to maintain the system wash temperature (generally at least the same volume of 145°F (62.8°C) water as the per cycle wash volume) can be hooked to the booster heater switch on the automatic washer timer. A time delay may be needed, as the hot water does not want to reach the in-line cooler before the wash solution. Check with your regulatory agency for guidance on protecting the water supply.

End of Milking Flush

End of milking flush is a common cause of added water in milk. Any flushing should be done after the swing line has been removed from the bulk tank. The water/milk mix can be used for feeding of young stock. To estimate how much water is needed to flush the lines, calculate the internal capacity of the milk discharge line from the milk pump to its highest point using Table 5. That is the volume to use. If this volume is too low to form a good slug for line rinsing, then use a larger volume of water and discharge to drain or fortify with milk replacer before feeding to young stock.

There are systems that use air for removing the milk from the lines rather than flushing with water.

Special Items

Backflushing

Backflushing can be an important milking parlor automatic procedure because teat cup liners can spread mastitis causing bacteria. Automatic backflushing units disinfect the milking cluster between individual animal milkings. Backflushing with 15-25 ppm iodine solution will significantly reduce the bacteria on teat cup liners.

- *Protection* – An intervening break to the atmosphere shall always be provided between the water and/or chemical solution and the milk and/or milk contact surfaces.

- *Water* – All water used shall be from an approved supply.

- *Air* – When air under pressure is used in contact with product or solution contact surfaces, it shall comply with the requirements for air under pressure contained in

Item 14r of the Grade A Pasteurized Milk Ordinance (PMO); Provided, that an exception to the piping requirement for the air piping downstream from the terminal filter may be granted when: 1) The piping is used only for filtered air; 2) At least one access point is available to determine cleanliness of the air piping; and 3) The piping is of a smooth, non-absorbent, corrosion-resistant, non-toxic material, including any adhesives used in joints. In some installations, a check valve may be required to prevent water and/or chemical solution from entering these air lines. See also, **"3-A Accepted Practices for Supplying Air Under Pressure in Contact with Product and Product Contact Surfaces, No. 604-05."**

Milk Transfer Stations

Milk transfer stations replace manual carrying of milk from the milking barn to the farm milk tank. Milk is poured from bucket milkers into moveable vessels (dumping stations) with pumps and hoses or vacuum lines for transfer to the bulk tank. Automatic covers to reduce entry of undesirable materials and an automatic shut-off to prevent unnecessary air movement through the milk shall be provided. A sensing device shall actuate pumps. If the vacuum system is marginal, provide a separate vacuum supply for the dumping station. Smooth tread tires shall be used on milk transfer stations.

Small diameter milk lines or one continuous piece of transparent plastic tubing that complies with "3-A Sanitary Standards for Multiple-Use Plastic Materials, No. 20-13" should be used. When cleaning after each milking, wash and dry with equipment designed for that purpose.

Milk Meters

Milk meters are often used in milking parlors to electronically measure milk production. Weigh jars continue to be used to measure milk weights. Milk meters that cause vacuum fluctuations should not be used on a daily basis. Many of the meters used on a monthly basis are not designed for in-place cleaning and care needs to be taken to be sure the equipment is cleaned properly. Meters that add lift to a milking system need to have the vacuum raised (1 to 1.5 inches) (3.5 to 5 kPa) to compensate for that lift on test days.

Compressed Air

Compressed air in contact with product or solution contact surfaces (for backflushing etc.) should be filtered, and piped through smooth, non-absorbent, corrosion-resistant, and non-toxic air lines (including adhesives for joints). Provide at least one access point to check the cleanliness of air lines; a check valve may be required to prevent water and/or chemical solution from entering air lines. (Reference; Grade A PMO, Item 14r and "3-A Accepted Practices for Supplying Air Under Pressure in Contact with Products and Product Contact Surfaces, No. 604-05.

Water

All water used should be from an approved supply. An intervening break to the atmosphere should be provided between the water and/or chemical solution and the milk and/or milk contact surfaces. Proper back flow preventers shall be installed where necessary to protect the farm water supply. (Refer to DPC030, *Potable Water On Dairy Farms*). Adequate volumes of hot and cold water under pressure should be available and check valves on cold and hot water lines are recommended to reduce thermal losses. (Refer to DPC058, *Sizing Dairy Farm Water Heater Systems*)

Cleaning and Sanitizing Milking Equipment

High bacteria counts in farm milk are often related to the milking system. The milk contact surfaces must be properly cleaned after each use to prevent contamination of milk.

Premium payments for quality milk have intensified the need to address cleaning and sanitizing problems. Farm operators should strive to produce milk with the following quality guidelines.

1. Less than 5,000 Raw Standard Plate Count (SPC)
2. Less than 20,000 Preliminary Incubation Count (PIC)

Some milk handlers may pay premiums for high quality milk.

All milking equipment, including fresh and treated cow equipment, must be thoroughly cleaned after each milking.

Current instructions for mechanical cleaning (CIP) and manual wash items shall be posted in the milkhouse by the certified dealer or chemical supplier.

Those responsible for the cleanliness of a milking system should thoroughly understand proper cleaning procedure. An adequate supply of potable water is needed, ideally soft, with a low dissolved mineral content. Proper disposal of the wastewater also reduces problems. (Refer to DPC030, *Potable Water on Dairy Farms*.)
An analysis of the water supply is needed to develop a proper cleaning program. When a water supply is changed, it should be analyzed to determine if adjustments of cleaner types and/or amounts are necessary. Checking the water analysis each year is required in several states.

Cleaners must be compatible with the characteristics of the available water to prevent deposition of mineral films on milk contact surfaces. Test the water supply for hardness to select a compatible cleaning agent. Test kits are available, and most suppliers of cleaning materials will perform this service for customers. Most cleaners are compatible with water that contains up to 10 grains per gallon of calcium/magnesium hardness. Specially formulated cleaners containing water conditioning chemicals are necessary for water that contains 10 to 30 grains of hardness. Water softening treatment may be advisable when a water supply contains 20 or more grains of total hardness. Water containing other solids such as iron or sulfates can also create difficult cleaning problems. Water softeners or iron filtration systems may be required to treat these problem water supplies. (Refer to DPC030, *Potable Water on Dairy Farms*.)

Phosphorus levels in the milkhouse discharge are a major issue in some areas, especially on large systems. Be sure you include milkhouse wastes when developing a nutrient management plan for your farm. Check with local conservation offices or the EPA to see if you are in a watershed area where nutrient management plans are required.

Safety Precautions

All Chemicals should be stored in a secured area to prevent accidental mixing, skin contact or availability to children. “Child-proof” pump guards are strongly recommended.

There is always some risk when handling and using toxic chemicals but developing the proper work habits and safety consciousness when using toxic chemicals can minimize these risks.

Listed below are some safety precautions that you should follow:

1. Never add water to chemicals; always **slowly add chemicals to water**.
2. Never manually add chemicals to hot water.
3. Never mix chlorine bearing compounds with other detergents or acids, as this may produce deadly chlorine gas.
4. Always wear eye protection and gloves when mixing chemicals.
5. Use extreme caution when mixing and/or handling caustics or acids. Mix in open, ventilated area.
6. Any chemical detergent contacting the skin should be flushed immediately with water for 15 minutes.
7. Obtain medical assistance at once.
8. Any chemical in the eyes should be flushed with water immediately for 15 minutes followed by an examination by a physician.
9. Remove any clothing that has been contaminated by a chemical detergent and flush affected area as outlined in steps 6 and 7.
10. Always wear protective footwear to prevent slips and chemical penetration.
11. **Read the label** on the product being used and/or material safety data sheet on the product. Observe all precautions and warnings on the label. Do not select products by color or odor. Warning labels are your signal that the contents are hazardous. Look for the words, "Danger" or "Poison" or "Irritant". The hazardous material will be listed, and the proper antidote given. Material Safety Data Sheets are available from each supplier.
12. **Follow directions on the label** as outlined on the cleaning procedure sheets, which should be available in the milk room.
13. Never spray **concentrated** chemicals.
14. Store chemicals properly at **all** times. They should be stored in a cool, dry, ventilated cabinet or storage room.
15. All cleaners and sanitizers should be properly labeled and easy to identify.
16. All chemical spills should be handled in accordance with the Material Safety Data Sheets.
17. Empty containers of hazardous chemicals must be thoroughly rinsed and disposed of according to local environmental regulations.
18. Reusable containers must be stored with plugs intact in a safe manner.

Procedures to Clean CIP Cleaned Pipeline Systems

The following is a cleaning procedure for milking systems which has been shown to give very satisfactory results.

Pre-Rinse

Flush the entire system with clean, tepid 95°-110°F (32.2°-43.3°C) water. This rinse should only take one pass through the system and then discharge to the drain. The rinse should continue until clear water is discharged from the line. Tepid water removes soils more effectively than does cold water. Water in excess of 120°F (48.9°C) can “cook on” milk residues if used for a pre-rinse.

Wash

Prepare chlorinated alkaline cleaning washing solution in 155°-170°F (68.3°-76.7°C) water at a concentration as determined by water quality tests and manufacturer’s recommendations.

NOTE: Sheep milk has a much higher solid and fat content than cow or goat milk so more cleaning solution will be required to properly clean the system)

Measure the cleaner and the water. The wash cycle should start at 155°- 170°F (68.3°-76.7°C) and drain at a temperature above 120°F (48.9°C) to insure good cleaning efficiency (pH 11.0-12.0, chlorine 100-120 ppm).

Circulate the cleaning solution through the system for about 6 to 10 minutes. Actual circulation time will depend upon the complexity of the installation and to a large extent upon observation and experience encountered with a particular system. Brush wash all parts not adequately cleaned by the circulating solution.

For systems with an automatic chemical dispenser, a test should be made on a regular basis to assure it is functioning properly.

NOTE: Manually clean the exterior of milking clusters prior to automatic washing. This helps minimize foreign material from getting into the milk system.

Acid-Rinse

Rinse the line with an ample volume of tepid or cold acidified (pH 3.5-4.5) water to remove all traces of cleaner solution. Test kits to determine approximate pH should be available from the installer.

NOTE: A cold acid rinse may cause a problem on systems that contain flexible plastic tubing or when wash temperatures are marginal. After rinsing, allow the system to drain completely. Inspect the line and integral parts such as milking clusters, pump, receiver, weigh jars, sanitary trap, etc. for proper cleaning. Milk contact surfaces should drain completely.

Sanitize

Just prior to milking, circulate an EPA registered dairy sanitizer solution through the line following directions supplied by the manufacturer. Allow the system to drain before milking is begun to keep sanitizer residues out of the milk.

Cleaning and Sanitizing Bucket Milking Machines

Rinse

Immediately after each milking, rinse each milking cluster by drawing approximately 1 gallon of tepid water 90º-120ºF (32.2º-48.9ºC) through the teat cup assembly. During the rinsing operation, the teacup assembly should be alternately be raised out of and lowered into the water, which will increase water turbulence and scrubbing action. After the rinse water has been drawn into the milker bucket, turn off the vacuum and rinse by swirling the water around the inside of the pail. Also rinse all outside surfaces.

Wash

Completely dismantle the machine and immerse all parts except the pulsator in a dairy detergent solution at the proper concentration. Thoroughly remove all traces of soil, using proper brushes. Prepare the detergent solution by filling the wash tank with 125º-130ºF (51.7º-54.4ºC) water and add a good quality alkaline washing compound to the water at a rate as determined by the water quality tests.

Liners
Clean the rubber and rubberlike parts just as thoroughly and in the same manner as the metal parts of the machine. This includes all liners, air hoses, and the vacuum hose running from the machine to the main vacuum line. Over time, rubber parts will become soft, cracked, rough, or spongy and should be replaced on a regular basis. Higher pulsation rates used on some small ruminant operations will cause more rapid wear of the liners and require more frequent changes.

Vacuum Hoses
Air vacuum hoses require cleaning just as often as other parts of milking equipment. Some instances of high bacteria counts in milk are caused by air and/or vacuum hoses that have not been routinely cleaned.

Acid Rinse
Immediately after washing, rinse all parts with tepid water acidified to pH 3.5-4.5 to remove residual traces of alkaline cleaner and to prevent deposition of minerals on equipment surfaces. Sanitation regulations require the washing and rinsing operations to be performed using a two-compartment sink. One compartment for washing and the other for rinsing.

Dismantling
After rinsing, dismantle the units and place on suitable racks to drain dry. Hang vacuum hoses to drain, if necessary. Store pails and strainers inverted on the rack. (See below for use of teat cup washers.)

Sanitizers
Just prior to milking, assemble the units and sanitize by flushing with a dairy sanitizer bearing an EPA registration on the label. Follow the directions on the sanitizer label for proper concentration, contact time and temperature.

Miscellaneous Items
- Clean pulsators and pulsator filters monthly or more often if conditions warrant. Follow manufacturer's recommendations.
- Accumulation of corrosion or foreign materials around a pulsator is an indication of pulsators which need cleaning. A further advantage to be gained from cleaning pulsators regularly is that the milking machine will function better.
- Air Filters must be changed regularly when using compressed air to evacuate a transfer station.

Teat Cup Washers
Automatic teat cup washers of various types are available. The safest course is to be sure that they have been approved for use by the appropriate regulatory agency and that the directions for use provided by the manufacturer are followed precisely. When teat cup washers are used, care should be taken to ensure that exterior surfaces of the teat cups and milker claws are maintained in a clean condition. To accomplish this, manual cleaning is required after each use.

Cleaning Pulsation Lines

An important part of milking system sanitation is the cleaning of vacuum lines on a regular basis. Condensation, milk droplets and airborne contaminants are frequently drawn into the vacuum line. Clean vacuum lines help to maintain optimum airflow within the milking system.

Vacuum systems should be designed to be easily cleaned. Lines should be looped with valves and tees provided for slug washing of the vacuum line. Wash solution must be able to flow through the entire vacuum line as is done when washing an around-the-barn pipeline system.

The distribution tank should be designed and installed to prevent wash solution from entering the vacuum pump. For example, do not install the outlet to the pump directly across from the inlet to the vacuum line. The tank should be able to hold a minimum of 15 gallons of solution without carryover to the vacuum pump. Tanks mounted overhead should be securely supported.

Cleaning should be done as soon as practical after milking to allow for ample drainage time. Dispose of the solutions in a proper manner. Animals should not be in the barn during the cleaning of the vacuum line to avoid exposing them to cleaning solutions. Care should also be taken to keep these solutions away from feed or bedding.

Vacuum lines need to be sloped to drain. All low spots should have automatic drain valves and clean-out plugs.

Stall cocks should be located on the top of vacuum lines.

Cleaning Procedure:

1. Close Valve #1 (See Figures 6 and 6a below)
2. Prepare a wash solution as directed on the label of product being used. A standard pipeline cleaner used monthly is adequate. Caustic cleaners are more dangerous and should only be used on severe buildups.
3. Start with the stall cock nearest the vacuum pump to clear the first section of pipe. Then progressively clean each section of the pipe. This should minimize the chance of plugging the pipe.
4. Shut off the vacuum pump and drain the system as necessary to empty the vacuum tank and lines. Check progress by progressively examining at the clean-out plugs. Make sure that the automatic drain valves do not become fouled.
5. Repeat steps 3 and 4 until entire system has been washed.
6. Put "Wash Pipe" into tee. (See Figures 6 and 6a). Close both valves and turn on vacuum pump. Allow vacuum to reach operating levels, then open valve 1 and draw in a minimum of 3 gallons of wash solution. Leave valve open for 10 seconds. Then close the valve and allow the system to reach operating levels. Open the valve and allow to remain open to clear slug of wash solution through the line.
7. Repeat Step 4. If the system is still not clean, repeat Step 6.
8. Repeat Step 6 on other sections of loop until all pipes have been washed.
9. Repeat Steps 3-8 using an acidified rinse following label directions for concentration.
10. Remove drain plugs to be sure entire system is drained. If there are no drain plugs, open valve 1 and valve 2 (See Figure 6a) and allow pump to run at least 30 minutes to dry the line.

Figure 6. Piping Schematic for Pulsation Air Line Wash System

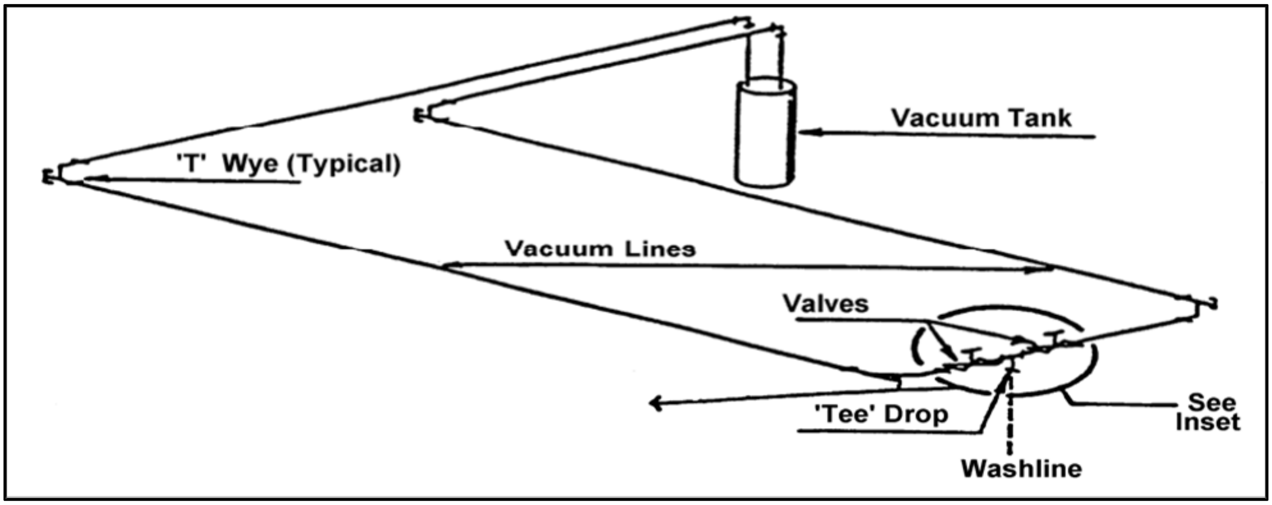
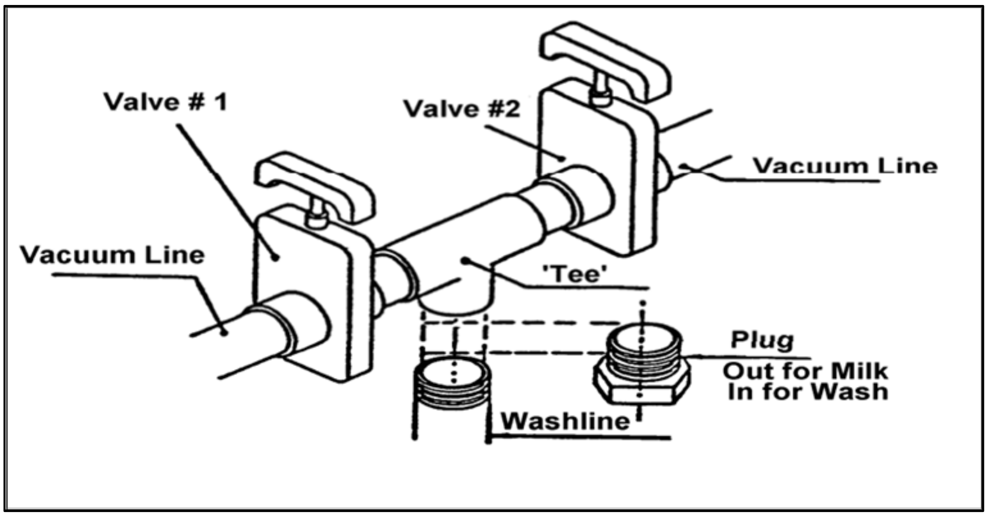


Figure 6a. Inset of Figure 6*



NOTE: *Tee and valve may be located next to distribution tank using only one valve. For airflow troubleshooting, the 2-valve system is more desirable. Also See Figure 2.

Cleaning Vacuum Trap Line

The vacuum trap line should be cleaned on a monthly basis. To wash this line, the trap shutoff (ball) needs to be removed or disabled. The receiver should then be flooded, washing the trap.

NOTE: **Do not admit more solution than the vacuum or balance tank can hold without allowing solution to get to the vacuum pump. The system must be allowed to drain between cycles. Use a hot detergent solution, followed by a warm, clear rinse, then hot acidified cleaning solution followed by a clear, warm rinse.**

Cleaning Farm Bulk Milk Tanks

Farm milk tanks that are not properly cleaned and sanitized encourage the growth of psychrotrophic bacteria, which affect the keeping quality and flavor of milk.

There are two basic methods of cleaning farm tanks: 1) a manual procedure, and 2) mechanical (CIP) method.

Manual Cleaning

- Pre-Rinse: Immediately after the tank has been emptied of milk, rinse all surfaces with tepid 90°- 120°F (32.2°-48.9°C) water. A warm water rinse at this time is vital in cleaning the tank. A cold-water rinse solidifies fats leaving a greasy film on the tank, while too hot rinse water can cause protein films to adhere to the tank surface.

- Brush Wash: Following rinsing, prepare 1 to 2 gallons of hot 155°-170°F (68.3°-76.7°C) chlorinated alkaline cleaning solution in a plastic pail. Follow the manufacturer's or dealer's directions as to the amount to use according to the water conditions. Maintain in the milkhouse an up-to-date cleaning chart that gives cleaner and sanitizer recommendations for current products.

- Brush all interior tank surfaces with the solution using a tank brush. Scrub all other surfaces with the brush including the underside of covers, bridge, and agitator shaft and blades.

- Drain the solution from the tank back into the pail. Disassemble the outlet valve and place in the pail to soak. Brush the outlet connection while the solution drains from the tank.

- Thoroughly brush the **outlet valve** and **calibration rod** with the solution in the pail. Then rinse these parts with tepid water. Use the remaining solution in the pail to clean the outside of the tank.

- Acid Rinse: Rinse all surfaces with tepid water. Finish rinsing with acidified solution (pH 3.5-4.5) to neutralize alkaline and chlorine residue and control mineral deposits on all surfaces.

- Sanitize: Just prior to milking, sanitize with an EPA registered sanitizer rinse solution prepared according to manufacturer's recommendations. Make certain that the sanitizer solution drains from the tank before milk is added to prevent sanitizer residues in the milk.

Clean In Place (CIP) Cleaning

Most of the CIP cleaning of farm tanks is accomplished by pressure recirculation of cleaning solutions through a spray device located within the tank.

Low foaming cleaners designed for CIP cleaning of dairy equipment are to be used according to manufacturer's directions to achieve satisfactory cleaning. Detergent concentrations must be adjusted to be in balance with the actual water temperature during cleaning. The maximum starting temperature for the cleaning solutions depends upon the type of tank to be cleaned. It is advisable to consult the tank manufacturer's specifications to determine what this may be. Ensure that cleaning solution temperature does not drop below 120ÅF (48.9ÅC), since lower temperatures may result in poor cleaning efficiency. All farm milk tanks should comply with **"3-A Sanitary Standards for Farm Milk Cooling and Holding Tanks, No. 13-09"**.

General Mechanical Procedure

- Immediately after milk is removed from the tank, rinse all surfaces with 90°-120°F (32.2°-48.9°C) to remove residuals.

- Disassemble manhole covers and gaskets and remove the calibration rod for cleaning manually.

- Prepare the washing solution adding the recommended amount of detergent to the automatic washer detergent container. If manually operated spray washing, pre-dissolve CIP alkaline cleaner in 4 to 6 quarts of water and add to the correct amount of water (enough water so that the circulation pump does not cavitate) at the proper temperature for the designed tank. **NOTE: Spray device should be examined on a routine basis to be sure it is not clogged by trapped material.**

- Turn on the CIP cleaning device and allow to operate until clean (6-10 min.). Make certain that the cleaning solution temperature does not drop below 120°F (48.9°C) during the wash cycle. The cleaning unit used must be designed for the style and capacity of the tank.

- After completion of the wash cycle, inspect the tank to ensure that all milk contact surfaces have been contacted with cleaning solution. Any items or surfaces not contacted by cleaner must be manually cleaned by brushing.

- Drain the solution from the tank, brushing the outlet connection and disassembled valve as the solution drains. Wash the outside of the tank with a good manual wash cleaner.

- Rinse the tank completely with tepid water, finishing the rinse with acidified solution (pH 3.5-4.5) to control mineral deposits and neutralize residual wash solution.

- Sanitize the tank just prior to use. Allow the sanitizer to drain from the outlet to prevent sanitizer residues in milk.

The problem areas in cleaning farm tanks are the outlet valve, tank covers, the agitator, agitator shields, calibration rod, and the support bridge for the agitator motor. These areas require careful attention.

Abrasive devices such as steel wool or stainless "sponges" should never be used on tank surfaces because they damage the polished surface.

Acidified rinse water and sanitizing solutions are most easily applied by means of commercial metering units that are attached to the rinse water hose. Such devices should be equipped with check valves to prevent backflow of chemicals into the water line.

Cleaning Milk Cans

- Pre-Rinse: Immediately after the can has been emptied of milk, rinse all surfaces with tepid 90°- 120°F (32.2°-48.9°C) water. A warm water rinse at this time is vital to good cleaning. A cold-water rinse solidifies fats leaving a greasy film on the can, while too hot of rinse water can cause protein films to adhere to the can surface.

- Brush Wash: Following rinsing, prepare wash solution of hot 125°-135°F (51.7°-54.4°C) alkaline cleaning solution. Follow the manufacturer's or dealer's directions as to the amount to use according to the water conditions. Maintain in the milkhouse an up-to-date cleaning chart that gives cleaner and sanitizer recommendations for current products. Brush all can and cover surfaces with the cleaning solution.

- Acid Rinse: Rinse all surfaces with tepid water. Finish rinsing with acidified solution (pH 3.5-4.5) to neutralize alkaline and chlorine residue and control mineral deposits on all surfaces.

- Storage: Cans should be stored in the milkhouse upside down on a draining rack to assure good drying and sanitary storage.

- Sanitize: Just prior to use, sanitize with an EPA registered sanitizer rinse solution prepared according to manufacturer's recommendations. Make certain that the sanitizer solution drains from the tank before milk is added to prevent sanitizer residues in the milk.

Troubleshooting Cleaning Problems

Examination Areas

- Examine the wash tank or vats used to hold the rinsing and cleaning solutions. If it is not clean and films are present, this is an indication of inadequate cleaning.

- Examine the rubber parts. If liners or claw caps on milking clusters feel slippery or greasy and offer no resistance when the finger is rubbed over the surface, this is also an indication of poor cleaning.

- Examine the probes in the receiver jar. If they appear soiled or are slippery to the touch, this is a further indication of a cleaning problem.

- Examine the receiver jar. It should be clear and free of film and water. This may also show up in other equipment in the system.

- Examine the milk line from the receiver group to the bulk tank. If the interior shows the presence of any film, the complete system may not be clean.

- Examine the interior of the pipeline. Examine the milk line and that part which slopes to the receiver. Frequently, water slugs will collapse and not clean the upper inner surface of the milk line. Also look at the high point where slugs may not be maintained through the upward slope of the system.

- Examine all weigh vessels for deposits.

Proper storage of cleaners and sanitizers will help prevent caking of dry chemicals and decomposition of various ingredients. Are they in an area that is relatively dry and cool? Are the covers for the powdered cleaners replaced after use? Are liquid containers properly capped?

In automated CIP cleaning systems, the role of the operator is sometimes considered secondary compared to the person operating a manually cleaned system. However, the use of proper materials in directed amounts should be confirmed as should the frequency of cleaning. Observing a complete cleaning cycle is essential because malfunctions may develop with automated systems.

NOTE: High capacity complex systems may require a cleaning specialist consultation.

Causes of Cleaning Problems

- Improper pre-rinsing temperatures. Too low a temperature will not remove milk soil adequately and may place a greater burden on the cleaning solution. Too high a temperature will cook on milk solids, creating a proteinaceous film. The proper temperature is 90°-120°F (32.2°-48.9°C) tepid water.

- Improper washing. This may result from such factors as:

- Failure to dissolve all of the powder in the powder receptacle or the wash tank. Undissolved particles of powder lying in the tank may cause unsightly detergent burns on the metal surfaces.

- Improper temperatures may arise from:
    - Hot water equipment capacities not adequate for the system.
    - Hot water heater problems arising from thermostat failures or burned-out heating elements.
    - Too great a demand on the hot water system prior to CIP cleaning. This may result from abnormal conditions.
    - Failure of the diverter valve (See DPC058, *Sizing Dairy Farm Water Heater Systems*). If the diverter valve that dumps out the rinse water after one circuit is not working properly and milky water is being recirculated, problems can develop. Conversely, if the diverter valve malfunctions in the wash cycle, the wash solution may be diverted to drain too soon. The draw valve used with automatic washers may open before the cleaning cycle is over or close before all the washing solution has drained out. If the latter occurs, neutralization of the acid rinse may occur.
    - Low water volume in the wash tank. This may result from improperly adjusted levels when the system was installed, or malfunctioning valves or electrical circuits within the cleaning unit, or a sink too small after update of installation.
    - Failure of automatic washer systems to deliver proper amount of chemical at the proper time.
    - Improper alignment of spray device in the tank or improper location of spray ball in the tank.
    - Spray devices used for the cleaning of the milk tank must be free of foreign material.
    - Insufficient water pressure for automatic washers which operate on water pressure.

- Improper treatment of the acid rinse water. This may result from failure of injector or pump to pick up sufficient product in the acid rinse.

- Lack of sanitizing prior to milking.

- Inadequate velocity and surface contact in the system. To maintain the velocity and surface contact, follow manufacturer's recommendations for the system.

- Air leakage into the system. This may result in the development of excessive foam while milking and excessive cooling during the wash cycle.

- If the milk inlets on an around-the-barn pipeline are not being cleaned adequately, it is usually because of slug breakdown. If sliding milk valves, located on milk carrying pipelines, have units attached during washing, the valve covers will not be washed. Gaskets and “O” rings in sliding milk valves must be replaced according to manufacturer's recommendations.

Problem Films

Hard White Films: Generally associated with a mineral build-up.
The most common of these are associated with:

- Failure to use adequate amounts of the proper detergents.
- Failure to treat rinse water with acid cleaner.
- Failure to sanitize with acid-type sanitizer if the rinse water is not treated.
- Adding hot water on top of alkaline detergents at the bottom of the sink. This is usually associated with those systems which dump the powder automatically into the tank at the beginning of the hot water filling cycle. If the hot water is not added directly onto the powder with rapid mixing, this trouble will develop.
- Improper removal of cleaning compounds from the system. This will manifest itself by the development of a white, cloudy film throughout the system as it dries.
- Improper drainage of the pipeline. If there are low and high spots in the barn or parlor, water will not drain out properly. As it slowly dries, water minerals will precipitate. This usually manifests itself as a white line at the bottom of the pipeline.
- Use of powdered sanitizers such as calcium hypochlorite in hard water (greater than 20 grains).

Hard Red or Orange Films: Usually associated with water containing abnormal amounts of iron and/or manganese.

- These films will show up on those portions of the system which carry only rinsing and cleaning solutions since the slightly acid pH of normal milk is sufficient to prevent this in the milk conveying portion of the system. The most common cause of this problem is failure to use acid-type materials, whether in the post-rinse, sanitizer, or periodic acid cleaning. Using a compound of chlorine that is compatible with the water in your system also may prevent this condition.

Soft White or Red-to-Orange Films: Not only will these appear in the line or milkhouse portion of the system, but they will also appear as a slime on probes and rubber milking machine parts. Causes of such films are:

- Pre-rinse – If the pre-rinse temperature is too high, protein will cook or bake on. Recommended pre- rinse temperature is 90°-120°F (32.2°-48.9°C).
- Washing – Too low a cleaning temperature will fail to activate the emulsifying, suspended and peptizing action of the detergent constituents. Too low a temperature at the end of the cleaning cycle will cause redeposition of the suspended proteinaceous soil. Recommended temperature is 155°-170°F (68.3°-76.7°C), end point no lower than 120°F (48.9°C).
- Detergent failure because of:

- Using a detergent with insufficient chlorine content. Minimum chlorine content at the beginning of the wash cycle should be 100 ppm. Complex systems with polysulfone components may require 120 ppm chlorine content.
- Low chlorine content can be due to an improperly formulated powder or one which has lost chlorine upon storage.
- Failure to use sufficient detergent to attain a desirable pH, e.g., over 11.0-12.0.
- Underestimate of volume of wash solution.

Hard Blue or Purple Film: This may be because of:

- Magnesium deposition resulting from improper chemical treatment of the water during washing or rinsing.
- Proteinaceous film.
- Inadequate rinsing of alkaline detergent solution.

Fat film: This is usually manifested by a greasy appearance and feel to the equipment, particularly with rubber parts. Droplets of water can be seen adhering to the interior of milking equipment. This is usually caused by:

- Too cold a pre-rinse below 90°F (32.2°C). Recommended temperature is 90°-120°F (32.2°- 48.9°C).
- Washing with low temperature water. Recommended washing temperature 155°-175°F (68.3°- 79.4°C). Recommended end point not below 120°F (48.9°C).
- pH too low due to using either cleaners with low alkalinity or insufficient cleaning compounds.
- Recommended pH between 11 and 12.
- Insufficient wash solution volume.

Water haze in system: This may appear as a very fine haze with some slight droplet formation in the interior of the lines and/or the releaser jar. It is usually associated with the first development of a fat or proteinaceous film. This will first manifest itself at the top of the receiver jar and/or the last portion of the milk line entering the milkhouse. Causes of this film are the same as those for greasy or proteinaceous film.

Dull, metallic film: This is a film which is not too common today. It has been observed when dissimilar metals have been used in a pipeline system. This can be rapidly determined with a simple magnet (all elements of the system must be either non-magnetic or magnetic) and this should include checking the sink or wash tank also.

Silica films: These films have a white to gray glazed appearance. The silica is a precipitation of silicates from the cleaner and/or water. The causes are many and varied but the major causes are poor rinsing, improper use of cleaners or the water supply composition. Special acid washes are usually required to remove these deposits.

Refer to DPC028, *Troubleshooting Residual Films on Dairy Farm Milk Handling Equipment*

REFERENCES

- ASABE standards ANSI/ASABE AD5707:2007 updated 2016 (for milking system construction and performance).
- ANSI/ASABE AD6690:2007 (Testing of milking systems).
- ANSI/ASABE AD3918:2007 (Terminology). ASABE has adopted the ISO standards for milking systems with deviations for changes needed to work in the US market. These are ANSI approved standards for the US.

APPENDIX

None.

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**This guideline was developed by contributors who are of experienced individuals in a related field(s). The acknowledged persons are included with their professional affiliations and may be contacted via a DPC Officer(s) and/or Task Force Director(s) for questions or concerns.*

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