Milking Equipment Components, Function, and Evaluation

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Few dairymen will deny that the most costly disease which they observe in their cows is mastitis. Bovine mastitis, although by no means a newly recognized disease is surrounded by more confusion on the means of control than any other disease. It has always been necessary to determine the cause of a disease before control measures can be developed. Therein lies the problem of bovine mastitis. All the years of research have only confirmed the complexity of the disease and its many etiological agents.

Although it has many etiological causes, it is basically caused by an interplay between mechanical forces (milking machine) and bacterial infection. Nutrition, heredity, and environment may also be involved but not to the extent of the previous two factors.

The role of the milking machine in mastitis is threefold. First, it acts as a vector in transmission of the organism involved. Secondly, it causes trauma which is necessary to incite many forms of the disease. Thirdly, it actively injects bacteria into the gland under certain circumstances.

Effective control of mastitis is one of the greatest challenges facing the dairy practitioner. The failure of many veterinarians regarding mastitis is strongly related to their ignorance of the milking machine. This may be due in part because many veterinarians do not think this should be part of their herd health program. However, this question was answered for us by the AVMA Mastitis Council in their recommendations of minimum standards for veterinarians who offer mastitis control programs. This was published August 15, 1973, in the AVMA Journal. Section III of that presentation lists the capabilities needed for a veterinarian. These should include the ability to determine the vacuum pump capacity to meter air flow capacity in the system, locate and determine capacity of vacuum controllers, and to compute pulsation rate along with milk rest ratios.

Most mastitis herd problems can be traced at least in part to a malfunction of the milking machine. Therefore, a good understanding of machine function is required for effective control procedures. I have seen many practitioners fail because they chase bacteria alone without correcting machine problems. Attempting to control mastitis through mechanical means alone can also be disappointing. Control procedures must take into consideration all responsible factors. At this time, however, we will dwell on the basic components and their function in a modern milking system. To one unfamiliar with the basic milking machine components, a look at the system may make it seem too complicated to comprehend, but if each component is isolated as an individual unit, the system is soon simplified. You also will find that many of the mechanical parts you first observe will not be involved in the basic milking system, but rather are accessories dealing only with the washing and sanitizing of the system. We are not going to dwell on any of these sanitizing systems.

With this in mind, we are now going to go into the basic components and their function.

Vacuum Pump

The vacuum pump is the heart of the milking system. It normally is a misnomer when we refer to it as a vacuum pump because we are more interested in amount of air flow that this pump will generate. This misconception will often get a dairyman in trouble because he looks at this gauge and it may register fifteen inches (15″) of vacuum yet he will have insufficient air flow to move the milk away from the claw resulting in teat end flooding. Pumps are rated in cubic feet of air per minute (CFM) they generate. CFMs may be expressed in two standards—the American standard and the New Zealand standard. One American standard is equal to two CFMs of New Zealand. Example: 10 CFMs on American standard are equal to 20 CMFs New Zealand standard. Most recommendations request a vacuum pump that will generate 10 CFMs of air flow per unit of the American Standard. Example: in a system of four units, it should have a pump capacity of 40 CFMs of air. In cases where milk meters, vacuum doors or other vacuum operated equipment are used, the pump capacity should be increased to compensate for them. There are different types of pumps based on the mechanical method of generating this air flow, one being the rotary pump which we will see most often in our dairies at the present time. The second type is a piston pump which is not used much any more because of its limited capacity. The third type is a water sealed pump which is not found very frequently in the cold parts of our country due to a climatic problem with freezing, although it is a pump that is used in large herds where high CFMs are required.

In checking a pump, it must be noted for belt tightness, oil level, unfamiliar noises, adequate exhaust part and adequate pipe size leading to reserve air tank. An instrument called an air flow meter is used to measure the CFMs the pump will produce. One of the most common defects found in milking systems is a pump with inadequate capacity.

Balance Tank

Balance tanks are sometimes mistakenly called reserve vacuum tanks. This is the tank which is connected to the vacuum pump through which all air moves from the system through the pump. Its purpose is to attempt to stabilize the vacuum in the milking system. We normally recommend at least five (5) gallons of tank per unit. This should preferably be located as near to the cow as possible and should have a vacuum regulator situated on it. It will normally have a flapper valve on the bottom for moisture drainage. This flapper valve can be a source of air leaks and should be examined on a milking system inspection.

There will be at least two pipes leading from the balance tank. One goes to the pulsator line and the other goes to trap on the milk receiver jar unit and on to the milk line. In some cases, there will be a single pipe leading from the balance tank. In this case, there will be a "T" some place in the line to go to the aforementioned places. This is undesirable because a single line will not permit sufficient air flow from the balance tank.

Pulsator

The pulsators have the job of opening and closing the rubber liner. They do this by allowing atmospheric air and then a vacuum to enter the space between teat cup liner and shell. In order to function properly, the liner must open completely for the milk phase and then close completely around the teat with adequate force for a good rest phase or massage action on the teat. The number of these openings and closings are designated as pulsation rate. The percentage of the time the liner is open compared to the closed phase is designated as milk rest ratio. There are two types of pulsators: alternating and single action.

Single action pulsators milk all four quarters at once. Alternating pulsators milk two quarters at a time. From the standpoint of mechanical factors active in mastitis, the alternating pulsator is definitely superior. By milking only two quarters at any one time, there is more even milk flow into the claw and milker hose at any given time. This reduces the tendency for flooding of milk lines which can interfere with vacuum flow to teat end. When we flood any one part of the system, it will create vacuum fluctuation. We must have stable vacuum for good liner action and also to prevent injection of contaminated milk back through the streak canal.

The most desirable pulsators have 50 pulsations per minute with a 50:50 milk rest ratio. Worn out, dirty pulsators are often the cause of mastitis problems. A vacuum recorder is necessary to competently check pulsators. It gives a graph which can determine the character of pulsation: that is, snappy or sluggish, and it also calculates the milk rest ratio.

Vacuum Controller

The vacuum controller or regulator, also known as a relief valve, is a critical part of the vacuum system. The pump is capable of creating a greater vacuum in the system than is required or safe. The controller admits air into the system at a constant set rate and lowers the vacuum to the required level. It should have air passing through it except during acute vacuum loss. Dirty, worn, sticking controllers have blown up many a herd. The controller should be located as close to the receiver as possible, usually on the galvanized side of the trap. Some are located in the pulsator line but this is wrong. The purpose of the controller is to regulate and control the vacuum from becoming too high. It also closes and the pump removes the air. If the controller is located as close to the milk line as possible, it will close rapidly if the vacuum level in the line drops. Controllers on the pulsator line do not act as rapidly as the drop in vacuum does not affect them as quickly. The drop must extend all the way back to the reserve tank and on out to the pulsator line before the controller can close. They are more effective when located close to the trap. In some cases, there is justification for adding a controller to the pulsator line. Controllers are rated as to the CFMs they can regulate, therefore, they must be matched to pump capacity.

The controller should be located where it will not get wet or dirty. It should have regular maintenance and care. The action of the controller is evaluated by bleeding air into the system for five (5) seconds. If the pump capacity is adequate and the controller is responsive, the vacuum level will return to normal in three (3) seconds or less. In fact, in a good system, it is impossible to lower vacuum level by bleeding air for five (5) seconds.

Milking Claw

The milking claw will consist of a chamber for the milk to flow to from the teat cup assembly. The teat cup assembly will consist of a teat cup and a teat cup liner. Together, their function is to apply the vacuum phase and the rest phase for the evacuation of the milk from the udder. If any of the previous components are inadequate or not functioning, they will affect what happens at the claw. All claws should have a small air inlet to speed milk flow from it. The opening should be checked for potency. Also, in some cases, liners will be used with air inlets on them. In this case, there should not be an air inlet in the claw. The principal function of the liner is to massage the teat in a manner to promote circulation of blood and thereby prevent engorgement of the teat with blood caused by application of a vacuum to a living tissue. A second function of a liner would be to confine the vacuum on the teat to the smallest area possible consistent with rapid milking. Liners are classified as narrow bore when internal diameter is ¾ inch and large bore when it is 1 inch or greater. The narrow bore is the most preferred. Present day liners tend to show a relatively small range of difference in their milking characteristics. These small differences in the performance of different liners have failed to indicate the relative importance of various design features. Liners under tension give noticeably faster milking because the proportion of the pulsation cycle during which milk flow is increased. All claws should have a shut-off valve which relieves vacuum before the claw is removed from the udder.

The final elements of the milking system which are the sanitary and non-sanitary line will be considered together.

The non-sanitary line or pulsator line should start at the balance tank, go through the parlor and back into the balance tank. The configuration will assure a constant vacuum to all points. It should have as few elbows as possible. Most new installations will be installed with plastic pipe which is fine because air travels faster through plastic than galvanized pipe.

The size of the pulsator line required depends on the number of units used.

Number of Units	Pipe Size
2-4	1¼″
5-7	1½″
8-12	2″

The pulsator line should be cleaned regularly.

The sanitary line can either be a high line above the operator head or a low line below the cow. Of course, the low line is far superior because the milk gets away from the cow much faster preventing teat end flooding and also requires less CFMs to remove the milk from the claw. The line should be looped from the receiver jar again to assure an even vacuum to all points. The milk line should be of adequate size. Two units require a 1½″ line, 4 units require a 2″ line, while for 9 units we have a minimum of a 3″ line. The line of stainless steel needs a minimum of 1″ per 10 feet slope, or for glass a slope of at least 1½″ per 10 feet. The entry port on the milk line must be located on the upper half.

Conclusion and Recommendations

Most dairymen and researchers believe that machine milking, either intrinsically or because of the way it is done, is an important factor influencing udder disease. Therefore, it is very important for the veterinarian to know and understand proper machine function and be able to make the necessary checks and evaluation of the milking system if he is to be successful in mastitis control.

Machine Check List

Date ________________

Dairyman ______________________ Address ______________________
Dairy Shipped To ______________________ Address ______________________
Fieldman ______________________ Address ______________________

Number of cows miked________________
Average dairy production________________
Average time spend milking________________

Step I: VACUUM -PUMP PERFORMANCE

Make & Model	HP	Maximum Static Vacuum	CFM	Scale (ASME or N.Z.)
________	____	________________	____	________
________	____	________________	____	________
________	____	________________	____	________
		Total CFM	____	

Step II: VACUUM DISTRIBUTION (CUSHION) TANK

Location ______________________ Size ______________________
Type Drain ______________________ Location ______________________
(Recommend self-draining on bottom of tank.)

Machine Check List

Step III: MEASURING SYSTEM CAPACITY

CFM = Cubic Feet of Air Per Minute
(Block off all vacuum controllers: CAUTION: DO NOT LET VACUUM LEVEL IN SYSTEM RISE ABOVE 16" DURING THIS PROCEDURE!!!)

Measuring standard used ____________(ASME or N.Z.)

System Capacity	CFM	Recommended Standards
1. Vacuum pump	_____	Minimum of 7.5 CFM-ASME or 15 CFM-N.Z. per unit.
2. Vacuum Dist. Tank	_____	Loss should not exceed 1 CFM-ASME or 2 CFM-N.Z.
3. Moisture Trap (Used to check header pipe and pulsator lines on the header system.	_____	Loss should not exceed 10% of pump capacity.
4. Pulsator Pipe (Used to check pulsator line on system with two lines from tank.)	_____	Loss should not exceed 8% of pump capacity.
5. Total System (no units)	_____	Single-loop line measure at either end of milk pipe at receiving jar. Dead-end line-measure at dead end.
6. Total System (With units on but not milking.)	_____	This is Reserve Air and should be equal to at least one-half and preferably two-thirds of the pump capacity (Total CFM in Step I.)

VACUUM PUMP CAPACITY:

1. Vacuum pump is adequate if the reserve air (Step V) is equal to 1/2 to 2/3 of pump capacity.
2. If the vacuum pump has the recommended capacity of CFM per unit and the reserve air is less than 1/2 of the pump capacity, look for restrictions, air leaks, or excessively long vacuum lines.
3. There may be cases where line sizes meet recommendations but are excessively long. In this case, it may be more practical to increase the pump capacity to more than the recommended CFM/unit to compensate for friction losses rather than revamping the whole system.
4. In cases where milk meters, vacuum doors, vacuum releasers or other vacuum operated equipment are used, the pump capacity should be increased to compensate for them.

Machine Check List

Step IV: VACUUM SUPPLY LINES

Line	Size (I/D Inches)	Recommended Sizes 1-3 Units	4-8 Units	9-12 Units
Vacuum Pump to Distribution Tank	______________	1 1/4"	1 1/2"	2"
Header (One Line from Tank)	______________	1 1/2"	2"	2 1/2-3"
Two Lines from Tank or Header				
To Moisture Trap	______________	1 1/4"	1 1/2"	2"
To Pulsator Line	______________	1 1/4"	1 1/2"	2"
Moisture Trap to Receiver Jar (Or Releaser)	______________	1 1/4"	1 1/2"	2"
Pulsator Line	______________	1 1/4"	1 1/2"	2"

(Recommend system to be as compact as possible with no dead ends in the pulsator lines.)

Step V: PIPE LINE

Size Line______________ Length______________ Feet Highest Point from Floor______________ (Should Not exceed 72")

Dead End______________ Single Loop______________ Position of Milk Valves______________
Amount of Slope______________ inches/2 feet (minimum 5/16" to 2 ft.)
Vacuum Level ______________
Uniformity of slope______________

Machine Check List

Recommended Number of Units for Line Size and Arrangement on Conventional System

Milk Line Size (Inches)	Dead-End	Single-Loop	Double-Loop
b 1½	2	4	8
2	4	8	16
2½	6	12	24
3	9	18	36

Where the facilities permit, the installation of a low-level milk line is much preferred when used with conventional milking system. In some cases, individual receiver (weigh) jar or other equipment is used to lift and transport milk with a separate vacuum supply. This separate vacuum allows the use of higher pipe lines and also more units to be operated on a given line size.

Milk Filter: Location__________ Type__________

In line filters of the type that interfere with milking vacuum are to be strongly discouraged.

Machine Check List

Step VI: MILKING UNITS

Type______ No. of Units________ Shells________
Inflations______ Milk Hose______ Size Hose _____
Reservoir in Claw ____________________

No. of Milkings Per Liner_____ = $\frac{\text{No. cows x 2 x days used}}{\text{No. of Units}}$

Number of milkings per liner should be according to manufacturers recommendations. (Most one-piece liners are good for around 1,000 milkings and ring type stretch liners can be used for about 500 milkings.)

Condition of:
Inflations______ Air Tubes______ Milk Hoses______
Bleeder Hole_____ Vacuum Level in Claw/Bucket_____
(Not under load)

Step VII: SYSTEM RECOVERY CAPACITY

This step is performed with system in operation but not milking (Vacuum controllers and all units operating).

Type vacuum controller (s)______ Location (s)______

(Prefer weight operated controller to the spring type. The controller should be located on the distribution tank or on the vacuum supply side of the moisture trap. The controller (s) should be of sufficient capacity, design, and location to maintain the same vacuum level throughout the system at all times.)

Machine Check List

1. Record operating vacuum level in one unit __________ inches
2. Let air leak into one teat cup for five seconds.
3. Time required for system to regain level of vacuum ________________ seconds.

If time required to reach operating vacuum level is more than three seconds, system is under capacity, or vacuum controller is malfunctioning.

Step VIII: PULSATOR ACTION - MILKING VACUUM

(Record while system is milking and under full load.)

Pulsator Construction: Master______ Unit______
Electric______ Pneumatic______

Alternate_________ Single Acting_________

Pulsations/Minute _________ No. of Dead Ends in Pulsator Line ________________

Pulsator Ratio: _________% time for Vacuum Phase
_______________% time for Air Admission

Milk/Rest Ratio: _________% milk (liner open)
_______________% rest (liner closed)

Vacuum needed to collapse liner ____________

(Consider collapse differential of liner being examined)

Milking vacuum range ________________

Pulsating vacuum range ________________

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