P-MM-1

Milking Machine Function and its Relationship to Udder Health

Lennart Petersson

IBA, Millbury, MA

There is more to mastitis control than milking equipment

Bedding, Manure and Milking Management are just three of many areas that need to be considered when facing udder health issues.

The majority of mastitis causing organisms are environmental in nature and for that reason the control of them becomes very important. Clean, dry and well managed bedding areas are of critical importance.

Informed estimates of direct and indirect milking machine effects range from about 6% to 20% of the overall new mastitis infection rates.

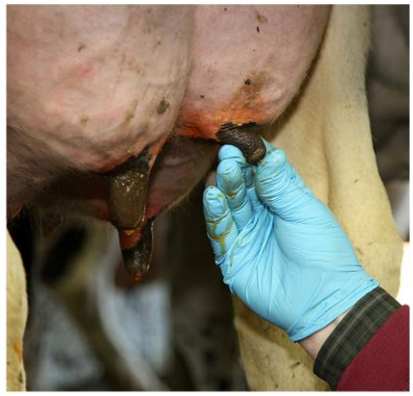
These effects are more likely the result from interactions between multiple factors rather than the effects of single factors

(G. Mein, 2004)

Milking machines can and sometimes do play a role in new mastitis cases; but more often then not, if they do play a role, it is more in combination with other factors.

Milking Equipment Factors

- Plays a role in mastitis control, but not nearly as important as cow cleanliness, animal handling and milking procedures.
- In many cases more of an issue with maintenance rather than installation.



If milking machines are causing a mastitis problem, it is more likely in relation to maintenance and up-keep than installation.

We are interested in milking equipment for more than just mastitis control

- Milking and labor efficiency
- Parlor conditions
  - Lighting
  - Parlor platform height
  - Ventilation
  - Automation
  - Others

To have milking crews perform up to expectation, it is very important that the conditions under which they work are comfortable. A contented and focused milker will perform better than a distracted uncomfortable one.

Milking Equipment Factors Associated with Infections

Inherent with Milking System

- Physical design of milking system according to manufacturer's guidelines.
- Adequate air flow capacities.
- Adequately responsive vacuum regulation.
- Properly functioning pulsation system.

Management of Milking System

- Selection of Inflations.
- Vacuum level and pulsation settings.
- Maintenance to include proper cleaning.

Research Based Standards Developed by

NMC

A global organization for mastitis control and milk quality

Procedures for Evaluating Vacuum Levels and Air Flow in Milking Systems

An updated version is currently in the revision process and as soon as that is completed, notice will be made of its availability.

Current Official Milking System Standards Based on NMC Guidelines for Proper Milking Machine Function

Pump Capacity:	Base 35 CFM (Cubic Feet of Air / Minute ASAE System) + 3 CFM / Unit + auxiliary (other vacuum using equipment
Effective Reserve:	Base 35 CFM + 1 CFM / Milking unit
Pipeline Vacuum Stability:	
During milking	Maximum 0.6" Hg
During static conditions	Maximum 0.2" Hg
Teat End Vacuum:	
During peak flow	10.5 – 12.5" Hg
Teat End Vacuum Fluctuations:	
During peak flow	
– High milk line	Not more than 3" Hg
– Low milk line	Not more than 2" Hg

Pulsation:

Phase & (Liner Position)	Usual %	Usual MS	Minimum %	Minimum MS
A (Opening)	10	100	-	-
B (Open)	50	500	30	300
C (Closing)	15	150	-	-
D (Closed)	25	250	20	200

MS = Milliseconds

NOTE: These guidelines are based on values measured during static conditions (no milk flow)

These guidelines are very important for continuous good udder and teat health.

Pipeline Slopes

The capacity of milk pipelines are dependent on the inside dimensions and the slopes of the line. The minimum slope on a line should be 1.5" for every 10 feet of pipeline. If difficulties arise with obstructions or low ceilings so that the 1.5" / 10 feet of slope on the pipeline cannot be achieved, the slope can start at the far point from the receiver group at 1" and increase toward the receiver jar. The maximum level of slope on a milk high line should be approximately 2".

The table listed below shows the changes in capacity in terms of maximum number of milking units being use on a milk pipeline relative to pipeline size and slope.

Number of Milking Units / Slope

Pipeline size	Slope in inches / 10 feet of pipe					
	0.6"	0.9"	1.2"	1.5"	1.75"	2.5"
2"	2	3	3	4	4	5
2.5"	4	5	6	7	8	10
3"	6	9	10	13	16	24
4"	21	(28)	(32)	(35)	(38)	(43)

Values in parenthesis – More than two operators per slope attaching milking units.

Mein et al., National Mastitis Council, 1993.

To make sure the number of milking units being used are not causing limitations in vacuum stability and overall milking, these guidelines need to be adhered to. When a milking system is limiting in terms of slope, it can be re-sloped with the lower sloped areas furthest away and with the greatest slope at or near the receiver group. If you have a 2 inch milk line and use 5 milking units, you need a slope of at least 2.5 inches per 10 feet of pipeline.

To determine if a milking system meets the requirements and industry standards, a series of tests need to be conducted.

Some of these tests will be conducted during time between milkings and when milking system is void of any fluids (static tests).

Other tests are conducted during milking (dynamic tests).

The following slides describe the various protocols for the static tests

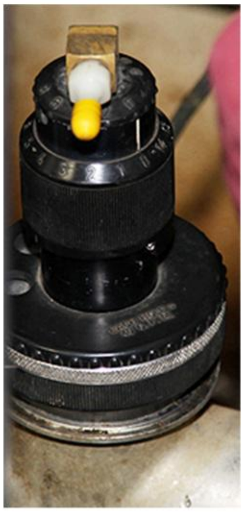
It is critically important to conduct evaluations under both static and dynamic conditions. Furthermore, spending time in the milking parlor during milking can be very revealing relative to milking performance and milking management.

Various Air Flow Measurements

- **Pump Capacity**
- **Pipeline Connected**
  (to calculate system leaks)
- **Manual Reserve**
  (to calculate regulator efficiency on conventional regulators; not applicable for variable speed drive systems)
- **Idle Effective Reserve**
  (to estimate milking unit usage, pulsators, auxiliary components and calculate true effective reserve)
- **True Effective Reserve**

True Effective Reserve is the volume of air in cubic-feet-of-air-minute (CFM) that is left over for successful milking performance. There are the guidelines of what those requirements need to be.

Commonly Used Air Flow Meters

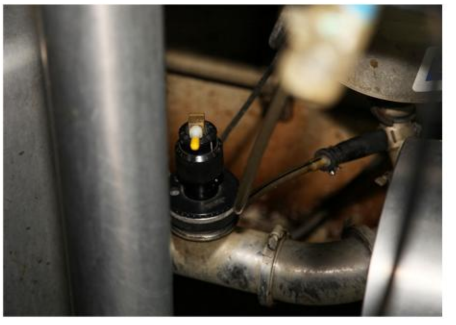


There are several types of air flow meters but the principles and use of them are the same.

Measure Air Flow in Milking Systems

The air flow meter should be attached to the milking system near the receiver group. With a two-receiver group system, two airflow meters should be attached – one on each receiver group, and the amount of air allowed thru the air flow meter should be balanced between the two air flow meters.

Most air flow meters used in the U.S. are according to U.S. standards. There are those that follow the New Zealand standards, which constitutes double the amount of air compared to U.S. standards.



All air flow values should be expressed in U.S. standards.

When using an airflow meter, it is very important that when each orifice (opening) is used, it is completely closed or opened. You cannot properly evaluate air flow unless this procedure is strictly adhered to. If an airflow meter has a gauge, do not use.

Air Flow Capacities of Components and Entire Systems

Pump Capacities, System Leaks, Effective Reserves, and other Air Flow Evaluations

When using the airflow meter, use a vacuum gauge that is connected to the system on the header pipe (if possible between the sanitary trap and the distribution tank) and at least 5 times the inside diameter on the pipe away from any elbow on other connector.

How to Measure Air Flow Capacities

- Use an approved air flow meter and either an accurate analog or digital vacuum gauge.
- Attach the air flow meter to an access connection in the milking system.
- Turn on the milking system.
- After reaching stable vacuum, open orifices in the air flow meter until a drop of 0.6”Hg is achieved.
- Calculate the amount of airflow based on the number of orifices that were opened to achieve the vacuum drop.

Idle Effective Reserve Evaluation

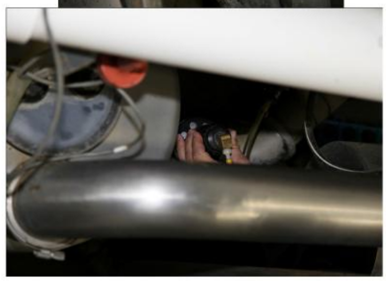
The test is being conducted under the following conditions:

- **Vacuum pump on**
- **Regulator system connected**
- **Pulsators operating / No vacuum to the milking units**
- **Observe vacuum drop of 0.6"Hg and calculate the sum of air flow**

To calculate <u>True Effective Reserve</u>:

Idle Effective Reserve *minus*
0.5 CFM / milking unit

See note below !



The adjustment of 0.5 CFM is for the volume of air flowing thru the milking claw or airvents in the inflations. The reason for this adjustment is that when the milking claws are not plugged, this deduction adjusts for claw vent air flow. If pulsators are not operating during this test, the adjustment should be 1 CFM per milking unit.

To Measure Vacuum Pump Capacity

- Disconnect vacuum pump from the milking system.
- Connect air flow meter to orifice in the milking system.

IMPORTANT:

- Open air flow meter equal or greater than rated pump capacity.
- Close up orifices to raise the vacuum to system vacuum level.
- Allow air in to the air flow meter to drop the vacuum 0.6”Hg. Calculate amount of air by the sum of the orifices opened. That value constitutes the pump capacity.

REQUIREMENTS:

Greater or equal to 10% of rated capacity. When calculating the expected pump capacity in a milking system, the equation is:

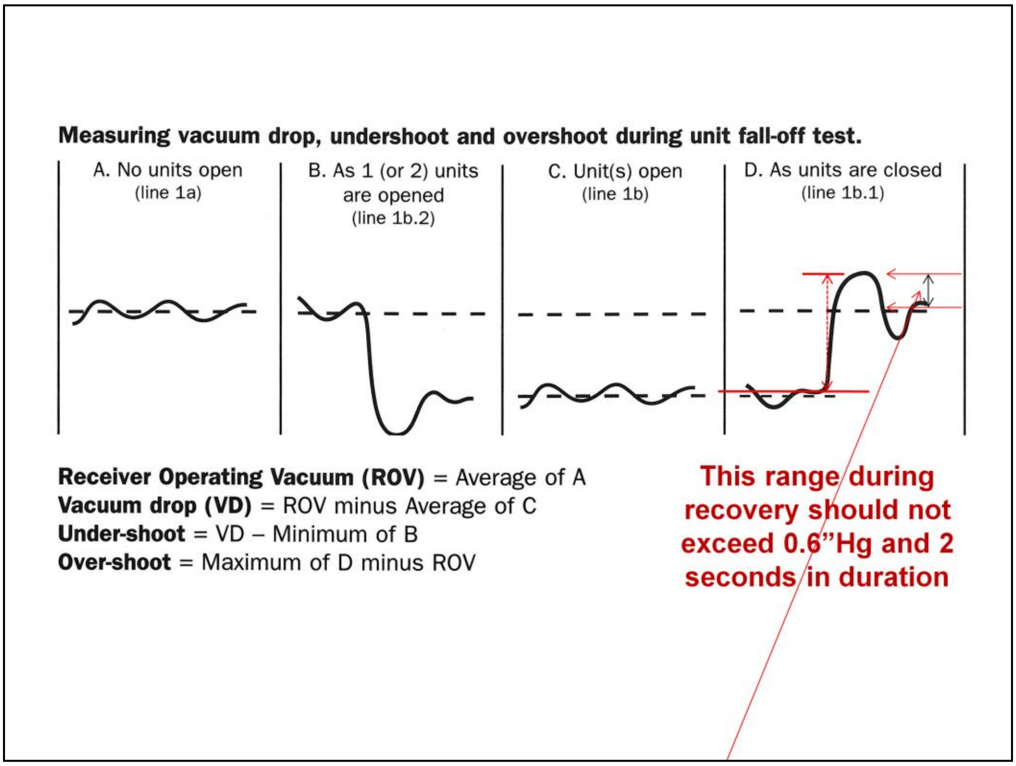
35 CFM + 3 CFM / Milking Unit

To measure the pump capacity you have to disconnect it from the rest of the milking system. YOU HAVE TO PAY SPECIAL ATTENTION TO OPEN ORIFICES ON THE AIR FLOW METER TO EQUAL THE RATED PUMP CAPACITY + 20 CFM. Attach the air flow meter and start the pump. IF THIS IS NOT PROPERLY DONE, DAMAGE CAN BE DONE TO THE VACUUM PUMP.

Milking Unit Drop-Off Test

- A simple test for milking system adequacy of milking system air flow capacity.
- If vacuum does not drop by > 0.6"Hg, it meets the requirement.
- One Unit Drop-Off Test for up to # 32 units and 1 milker.
- Two Unit Drop-Off Test for greater than # 32 units and/or 2 milkers with any size milking parlor.
- Measure Vacuum Drop: 0.6"Hg. When this drop in vacuum has been reached, the test is complete.
- The same test should be performed for milking systems that have conventional and variable speed drive system.

For standard tests, the Drop Off test is adequate. If problems are apparent, regular air flow tests using an airflow meter with an electronic vacuum gauge will be needed for proper diagnosis of air flow capacities.

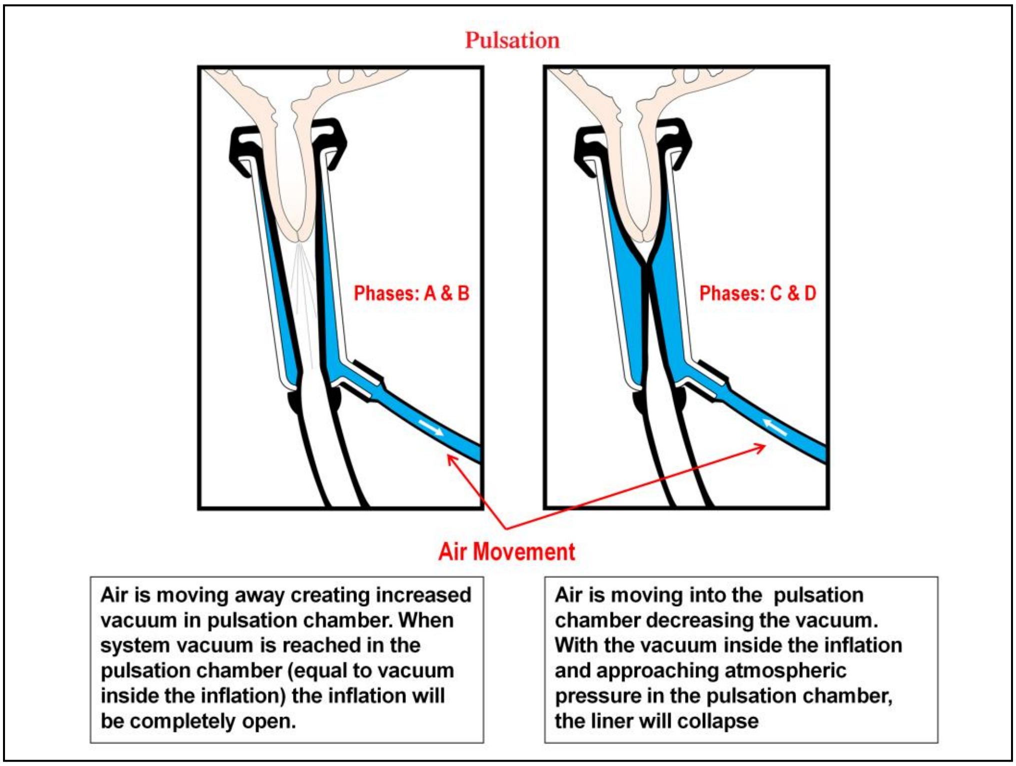


It is important to have a regulation system functioning with acceptable responsiveness both in the level of "over shoot" and the time it takes for the milking system to reach system vacuum level again after this test.

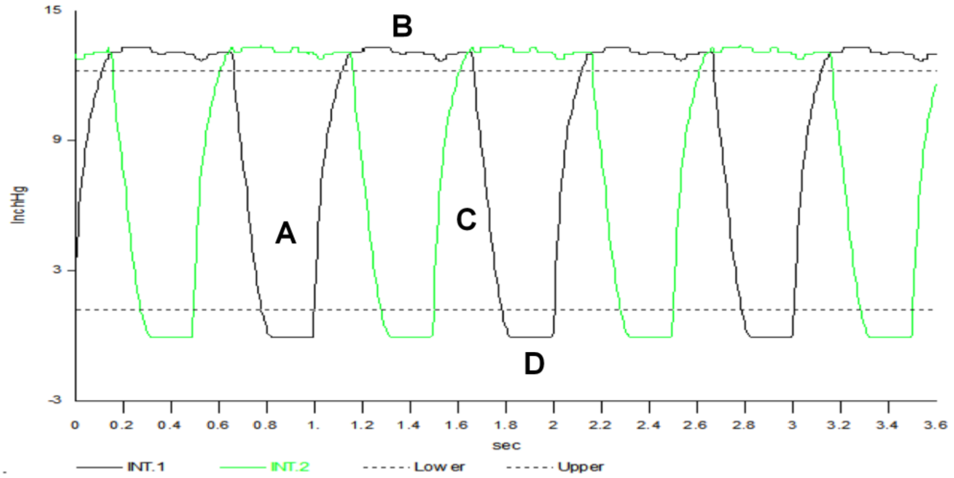
Protocol for collecting pulsation data:

- If the pulsation is of alternating type, determine if it is side-to-side or front-to-rear pulsation.
- If a two channel vacuum recorder is used, the tubing should be connected to two short air tubes (each representing one of the sides of the pulsation) on one end and to the pulsations chamber port on the inflation shell on the other.
- Teat plugs has to be used and vacuum should be extended thru the claw and inflations during the test.
- The procedure is shown in the photo below.

Proper connection for the test



The principal phases of pulsation.



Phases of pulsation – Vacuum conditions in the pulsation chamber collected from short air tube

A : OPENING B: OPEN C: CLOSING D: CLOSED

There are a lot of variations in the appearance of pulsation graphs. These graphs will help in diagnosing problems with the pulsation systems.

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index: A225, 02/29/2008 12:22
FARM: IBASCHOOL  TESTER: LENNY
CURVE MEASUREMENT
LABEL: PULSATOR 17

Vacuum value in inchHg
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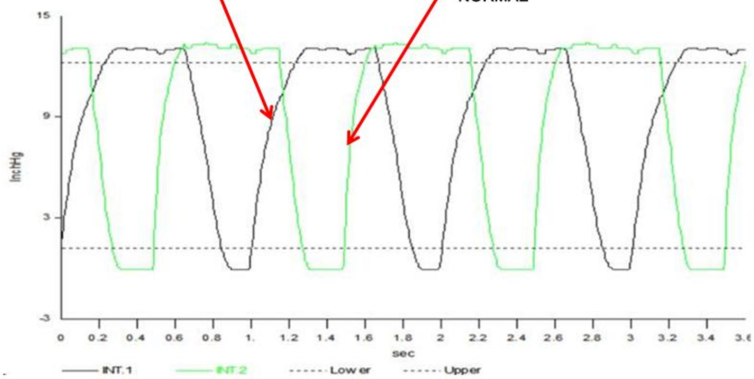
The table of data collected can reveal problems with the pulsators. The characteristics of the various phases of pulsation may vary from pulsator types but can still help resolve problems if properly investigated.

SENSOR	VACUUM	PRESSURE	A	B	C	D	A+B	C+D	LIMP	PULSE
INT.1 SENSOR 1001	13.1	0.0	217	455	176	153	672	329	8	59.9
			21.7	45.5	17.6	15.3	67.1	32.9	0.8	
INT.2 SENSOR 1001	13.4	0.0	106	558	121	216	664	337	8	59.9
			10.6	55.7	12.1	21.6	66.3	33.7	0.8	

RESTRICTIONS

NORMAL

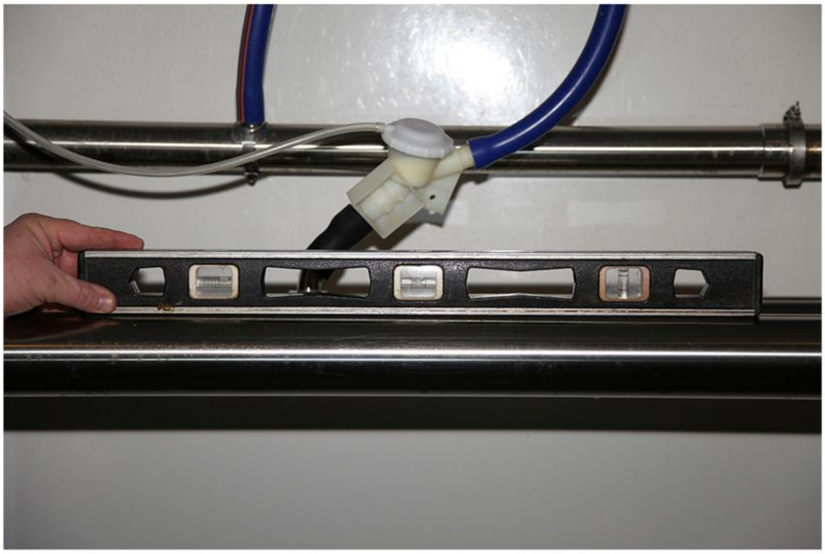


Measurement of slope of milk and pulsator lines

Suggested procedures:

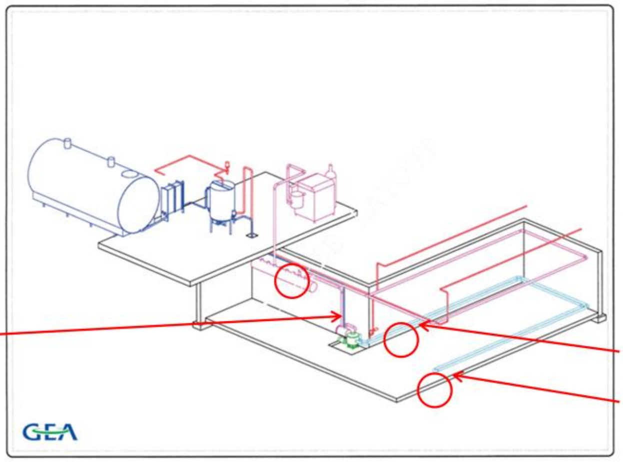
- Use a 2-foot level and place it on the sloped pipeline to be measured.
- Lift the end of the level that represent the lowest end. After reaching leveled condition:
  - Measure the bottom of level and top of pipe.
  - Multiply that by 5. The value achieved represents the slope in inches/10 feet. It should be at least 1.5”/10 feet of pipe.
  - The slope needs to be continuous with a positive slope throughout. Slope interacts with pipeline size for total capacity.

Measurement of Slope of Milk and Pulsator Lines



Proper slopes in milk pipelines is very important for proper fluid flow during milking and for proper cleaning of milking systems.

Measure vacuum conditions at several locations in the milking system without milk flow in the system.



Use installed test ports or milk inlets. The variation in the vacuum level should not exceed 0.2”Hg. Higher variations may indicate restrictions and need to be investigated.

Vacuum Regulation

Types of Regulation Systems

- Conventional
- Single
- Diaphragm
- Spring loaded
- Remote sensing
- Variable speed
- Electronic sensing

Location of Sensors or Conventional Regulators

Closest to possible air leak.

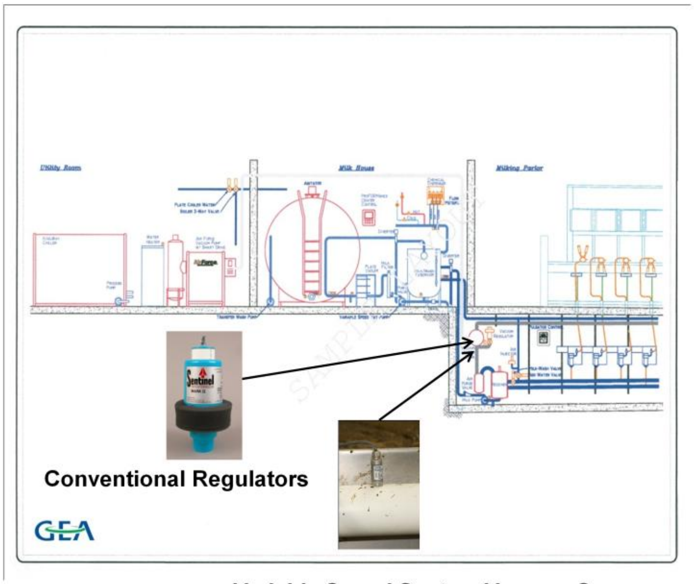
For stanchion barn and single receiver milking parlor:

On the non-milk side near the sanitary trap.

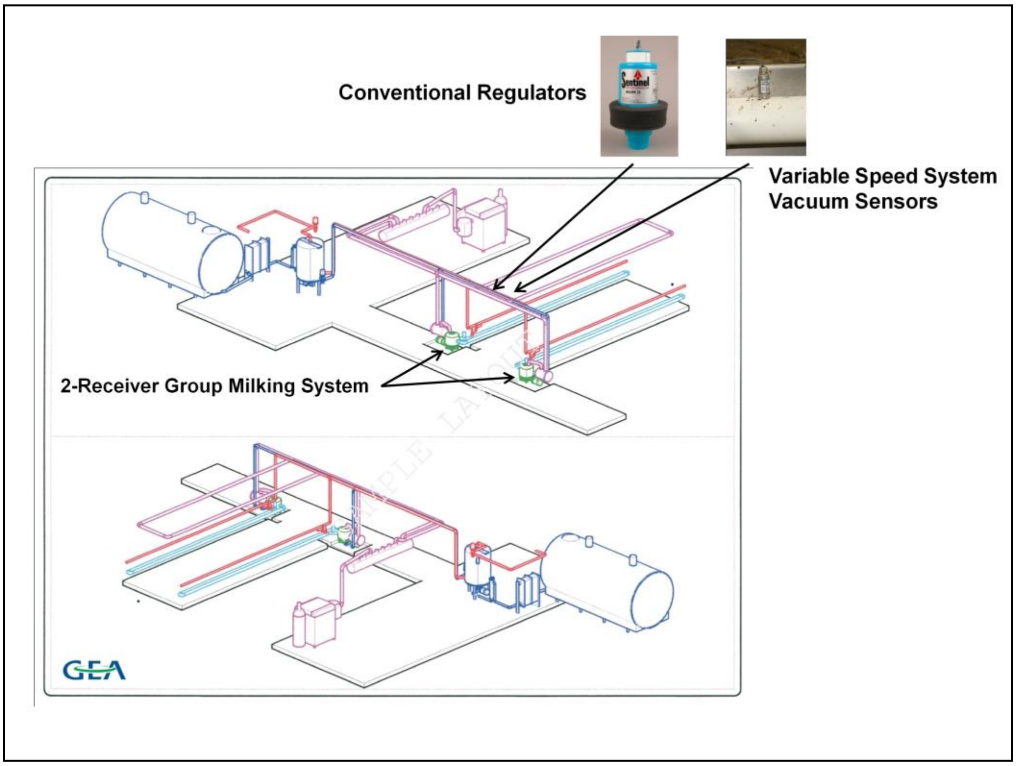
For parlors with two receiver groups:

In a location where the sensor can sense the vacuum changes from both sides equally.

Location of Sensors for Variable Speed Drive Systems and Conventional Regulators should ideally be on the non-milk side as close to the sanitary trap as possible. If a system has a remove sensing conventional regulator system with "dumps", the sensing unit should be located near the sanitary trap and with the "dumps" located near and the back side of the distribution tank. See slide #34.

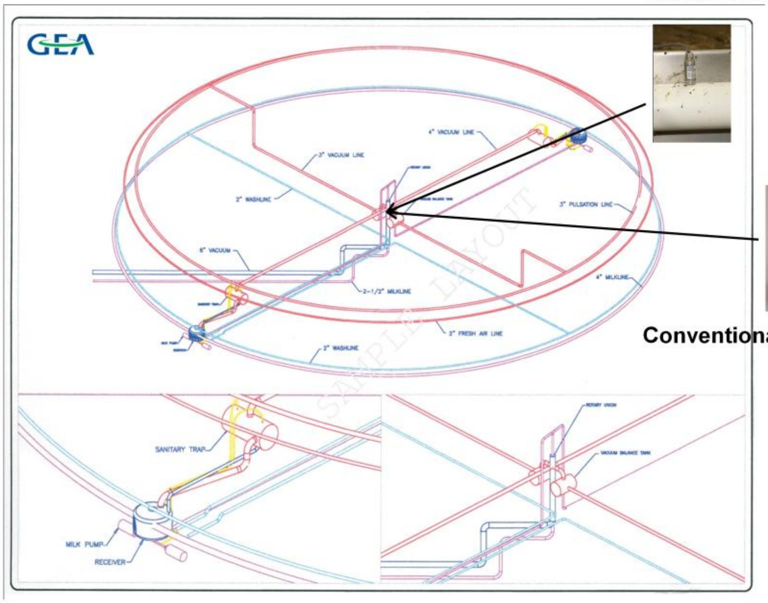


Variable Speed System Vacuum Sensors



Conventional Regulators
Variable Speed System
Vacuum Sensors
2-Receiver Group Milking System
GEA

Rotary Milking System with Two Receiver Groups



Variable Speed System Vacuum Sensor

Conventional Regulators

Location of vacuum sensors should be as close to the expected location of leaks into the system, that being the milking parlor.

In the case of a stanchion barn, the around-the-barn pipeline.

The most common location is on the non-milk side of the receiver group and at least 5 times the internal dimension of the pipe from elbows.

Sometimes, as it is in this example, it is difficult to find such location.

Conventional Regulator Diaphragm Style

Conventional regulators need timely maintenance for proper performance.

- When regulators are used as a safety release valve in a system using a variable speed drive, (VSD), the setting should be equal or greater than 1"Hg above the set vacuum level.
- If this is not done, it may interfere with the electronic sensor for the VSD system.
- The vacuum setting on regulators should be checked regularly. They do have a tendency of changing.

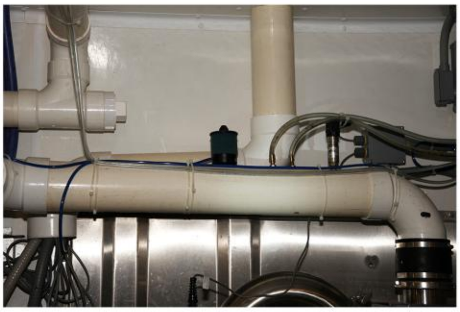
These considerations are critical for proper performance.

It is also recommended that a digital vacuum gauge is installed in a well-seen location for daily reference on vacuum level. A note of the proper vacuum level should be located near the vacuum gauge for proper cross reference.

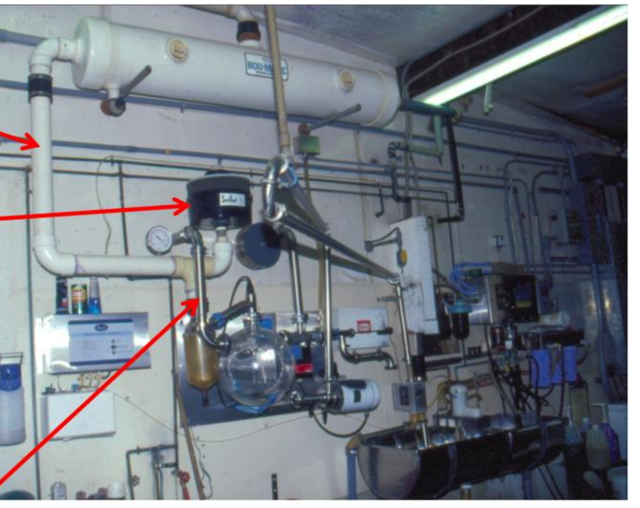
Remote Sensing Conventional Regulator

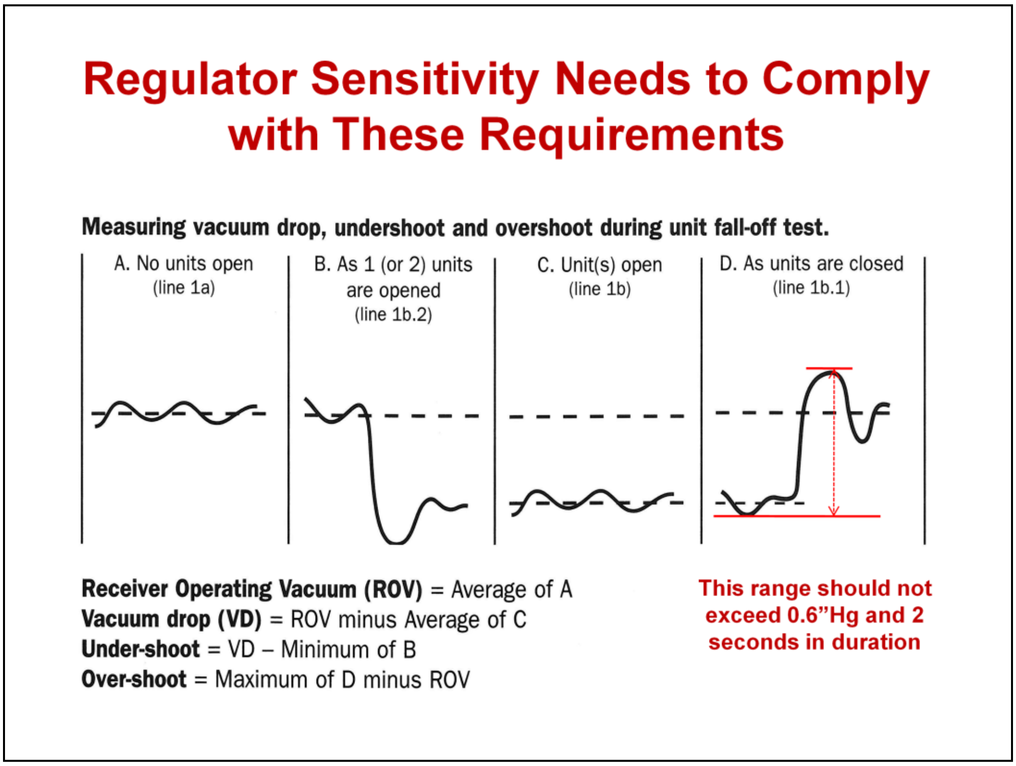
The tubing from the remote sensor should not exceed 32 feet in length. If more than one dump is used, the length of the tubing from the splitter to the dumps has to be of equal length.

The sensing unit should be located near the receiver group, as can be seen above and the "dumps" can be located on or near the distribution tank.



Proper Location of Regulator or Sensor





See further notes on slide #19.

Dynamic Testing

- To properly evaluate the performance of a milking system it needs to be tested during milking.
- The settings of vacuum level and pulsation rate and ratio should be governed by the type of inflation being used and that advise should be provided by the manufacturer of the inflation.
- To determine if the proper vacuum level is used, the measurement needs to be collected at the milking claw at peak milk flow of milking. The average vacuum level needs to be collected from at least 8 to 10 fast milking cows and calculated by the electronic vacuum recorder.

“If it doesn’t make a difference at the teat end during milking… it doesn’t make a difference” *– John Dahl*

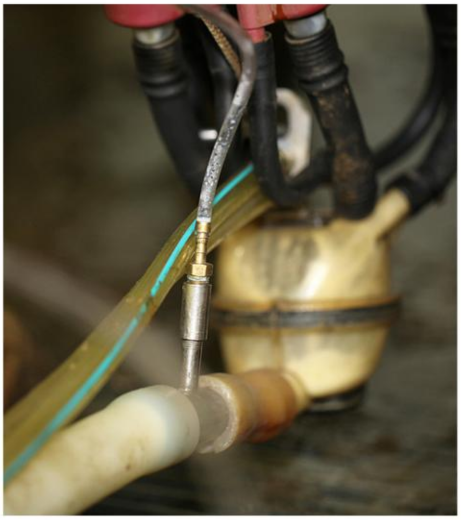
The guidelines for milking system settings should be governed by what the cow is exposed to during milking unit attachment. She needs to be milked efficiently and with comfort.

Measuring Vacuum Conditions at the Milking Claw During Milking

- Use a T-adaptor connected in front of the milking claw and into the milk hose.
- Connect an electronic vacuum recorder and proceed to collect vacuum conditions during milk flow. The critical time for this data collection is at PEAK MILK FLOW.
- Once reaching peak milk flow, the data collection should not be any longer than 12 to 15 seconds. <u>Store the data by allowing the testing device to calculate the average vacuum level</u>.
- Repeat for a total of 10 cows. Calculate an average of those ten cows.
- If using a PtV vacuum recorder, use “Course Measurements” and pick the “course” with the lowest vacuum level as the referenced vacuum level.

Measuring Vacuum Conditions at the Milking Claw During Milking

Test port should be installed in front of the exit of the milking claw and the nipple should be located up, as shown in this photograph.

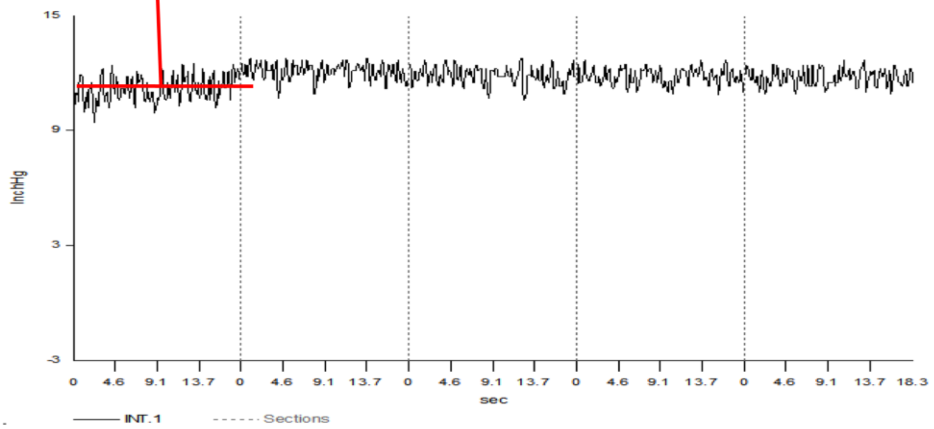


LABEL:

Vacuum value in inchHg

INT.1 SENSOR COURSE	1	2	3	4	5
WORKVAC.	12.9	12.9	12.9	12.9	12.9
AVG.VAC.	11.2	12.1	11.9	11.8	11.8
MAX.VAC.	12.5	13.0	12.8	12.8	12.7
MIN.VAC.	9.4	10.9	10.7	10.9	11.0
VAC.+	1.3	0.8	0.8	1.0	0.8
VAC.-	1.7	1.1	1.1	0.8	0.7
VAC.DROP	1.7	0.8	0.9	1.1	1.1

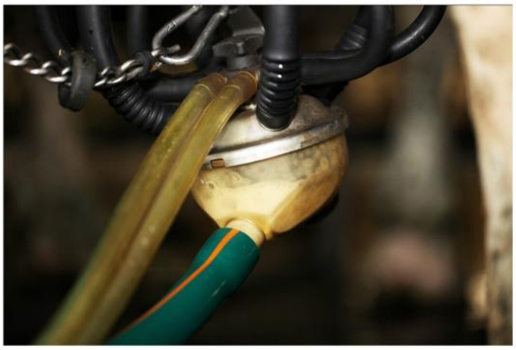
Using course measurements allows for averages to be calculated with intervals of 20 seconds. The lowest value will represent peak milk flow average. This should be used to set proper system vacuum levels in a milking system. In this case, the average vacuum level for this evaluation was 11.2”Hg.



Recommended guidelines for milking claw vacuum during milking for use with most inflations available on the market

10.5 to 12.5 inches

measured at claw outlet at Peak Milk Flow for most cows



This setting should be governed by inflation manufacturer’s guidelines

When using Milk Flow Sensors, it is important that the settings are correct for efficient and timely removal of the milking units.

Using scanners for this purpose is a very accurate way to calibrate the sensors.

Use of Flow Simulator

- An accurate and convenient way to evaluate milk flow meters.
- The convenience is that it can be conducted without cows being used for the test and it removes the problem of variability of cow flow rates.

- It is an easy way to standardize this test.
- Average cows flow at 1 gal/min.
- Top end cows flow at 1-1/2 gal/min.

The milking parlor should be a pleasant place for milkers and cows alike. The milkers need to feel comfortable doing the work and the cows need to be treated positively.

Milking procedures and cow handling should be consistent, effective and gentle. This will optimize oxytocin release and milking performance.

It is critically important that the milking system is operating properly and according to standards and guidelines so that the cows are not limited by discomfort and poor performance of the milking parlor. Cows are creatures of habit and may be effected by previous exposure to discomfort.

Cow handling during the entire process of milking should be calm. Stressed cows can create hormonal responses that block oxytocin release. This negatively effects milking performance. The time cows stand in the holding area should be as short as possible. The time spent in the holding areas should not be stressful.

System Components Involved with Vacuum Stability During Milking

- Vacuum pump – air flow capacity
- System leaks
- Line flooding
- Number of milking units per slope
- Slope on milk line
- Line sizes
- Size and length of milk hose
- Try to achieve gravity flow of milk thru the milk hose
- Position milk flow sensors to help achieve gravity flow
- Excess air admissions – properly vented milking units
- Regulator location, design and responsiveness
- Properly set detachers
- Properly set vacuum level and pulsation

Vacuum instability during milking can be caused by many things. A systematic evaluation of the various parameters in a milking system needs to be performed and corrections made as soon as possible.

Factors Related to Vacuum Stability During Milking

- Properly stimulated cows before milking unit attachment.
- Attachment of milking units.
- Liner placement on the teats.
- Milking claw alignment.
- Provide proper milking claw support.
- Provide proper detachment of milking unit.
- Make sure proper venting of milking unit / inflations are maintained.

Producing an excellent dairy product is the ultimate goal