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The Milking Machine

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THE MILKING MACHINE

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There are two methods for removing milk from the udder of a cow—milking by hand and milking by machine. Both methods operate by creating a difference in pressure measured in millimeters (mm.) of mercury (Hg).

Approximately one minute after a cow has been properly stimulated to "let down" her milk, as much as 60 mm. mercury pressure may be built up within the udder. When the cow is milked by hand, a positive pressure (more than 60 mm. mercury) is created around the outside of the teat and the milk is *squeezed* out. When a milking machine is used, however, a negative pressure is created around and on the end of the teat. The pressure in the udder becomes greater than the pressure outside the teat and milk simply *flows* out. It would appear therefore that all that is necessary to remove milk from the udder is to insert the teat in an enclosed system, create a partial vacuum by removing air from the system, and let the milk flow.

Milking a cow with a machine is not that simple a matter, however. When a continuous vacuum is applied to living tissue, the circulation is cut off. Blood vessels and capillaries rupture, tissue becomes irritated, and mastitis may result. Therefore a milking machine must be designed, not only to create a vacuum, but to admit air to the enclosed system to restore circulation around the teat. In addition, the machine must move milk, sometimes for great distances.

No milking machine will cause mastitis if properly installed and managed. Even though there are many different brands, styles, and kinds of milking machine systems available, all are designed to do an efficient job of milking. Although one system may operate at a different speed or ratio, all systems operate on the same principle and all have four essential components:

1. vacuum system
2. pulsator
3. milking unit
4. milk-flow system

THE VACUUM SYSTEM

The vacuum system serves a dual purpose: it removes air from around the teat permitting the cow to be milked, and it sucks the inflation shut to provide a massaging action and restore circulation to the teat.

PUMP AND MOTOR

Moving air rapidly from a milking system is absolutely essential to udder health. The motor and pump are designed to move a specific amount of air which is measured in cubic feet per minute (CFM). The amount of air a pump may be required to move depends on the number of units, the size and diameter of the teat cup shells and inflations, the pulsators, the number of vacuum controllers, the number of stall cocks, and the type of unit (pipeline or bucket).

In addition, since the efficiency of the operator and the equipment and the number of leaks in the system are not known, a reserve capacity must be included. Use the following information as a guide for determining the adequacy of a particular system, pipeline or bucket:

A Three-Unit, Bucket-Type System*

3 units @ 2.5 CFM/unit =	7.5 cubic feet
1 vacuum regulator @ 2 CFM =	2.0 cubic feet
20 stall cocks @ 1/10 CFM =	2.0 cubic feet
Total consumption per minute =	11.5 cubic feet
Reserve requirement of ⅓ =	4.0 cubic feet
	15.5 Total CFM Requirement

A Three-Unit Pipeline System*

3 units @ 2.5 CFM/unit =	7.5 cubic feet
1 vacuum regulator @ 2 CFM =	2.0 cubic feet
3 stall cocks @ 1/10 CFM =	.3 cubic feet
3 milk valves @ 1/10 CFM =	.3 cubic feet
1 releaser @ 4 CFM =	4.0 cubic feet
Total consumption per minute =	14.1 cubic feet
Reserve requirement of ⅔ =	9.3 cubic feet
	23.4 Total CFM Requirement

*Rated under American Standards

The CFM rating of vacuum pumps is expressed in one of two ways: The ASME Standard (American Standard) or the New Zealand Standard. The difference in the ratings results from measuring the volume of air at two different pressure conditions. The American Standard is based on volumetric delivery rate at normal atmospheric pressure (14.7 pounds per square inch Absolute), while the New Zealand Standard is based on the volume of air delivered at 15 inches of mercury vacuum (7.34 pounds per square inch Absolute) .Two volume units of air at 15 inches of vacuum (½ an atmosphere) equal one volume unit of air at atmospheric pressure. For example, if a pump requirement is 16 CFM under the American Standard, it would be 32 CFM under the New Zealand Standard. The difference in terminology does not refer to a difference in the pump's capacity or size. Both the American and New Zealand Standards are acceptable, without restriction.

VACUUM SUPPLY TANK

The vacuum supply tank is attached close to the pump to insure an even distribution of vacuum throughout the system and to prevent fluctuation of vacuum. The recommended size is five gallons per unit.

VACUUM CONTROLLER

The vacuum controller or regulator is attached between the vacuum supply tank and the first stall cock on the vacuum line. The regulator prevents the vacuum level from exceeding a set pressure by admitting atmospheric air as necessary.

There are several types of regulators. The most common are the ball, the cone, and the sliding-sleeve valve, all held in a closed position by a dead weight until the vacuum level exceeds the set limit. Vacuum regulators held in a closed position by springs are not recommended since the spring has a tendency to weaken and permit excessive vacuum levels.

Most vacuum regulators are adjustable, but only a trained service man should adjust them. The operator should clean the regulators at least once a week to prevent restriction of air movement and to insure free movement of parts.

VACUUM LINE

An adequate pump is of no value if the vacuum line can not accommodate the movement of air. Install a vacuum line of sufficient size in as straight a line as possible and in a continuous circuit. This permits a more even flow of vacuum and reduces the possibility of line blockage. Recommended vacuum line sizes are shown in Table 1. Make sure low points in the line have automatic drains to facilitate removal of water or milk accumulation. Use pipe tees instead of elbows for corners so the line can be disjointed for cleaning. In addition, slope the line for proper drainage.

Table 1. Recommended Vacuum Line Sizes

Number of Buckets	Number of Units Pipeline	Line Size (Inches)
1-3	1-3	1¼
4-7	4-7	1½
8-12	8-12	2

Plastic pipe may be used for vacuum lines if it is of high quality. Medium or low grade plastic pipe will collapse under vacuum, however, and is affected by hot water and cleaning chemicals.

STALL COCKS

Stall cocks are either automatic or operated by hand. Either type is satisfactory, but both are subject to wear and must be checked periodically for leaks. Install on top of the vacuum line.

VACUUM CONTROL GAUGE

The vacuum control gauge indicates the amount of vacuum in the line. Install the gauge on the line where it may be read easily. Check the gauge periodically with a mercury column to assure accuracy.

Remember . . . the vacuum gauge only records the vacuum present in the line, not the vacuum at the teat cup or the amount of air moved through the line. A removeable vacuum gauge can be used to check vacuum level at the teat cup during the milking operation.

THE PULSATOR

The pulsator directs atmospheric air into the chamber between the teat cup liner and the shell and then withdraws this air by opening a port into the vacuum system. This alternating action creates a massaging effect as the inflation collapses against the teat.

The pulsator action is defined in terms of rate and ratio. Rate is measured in pulsations per minute and refers to the number of times a pulsator opens (milks) and closes (massages) per minute. Ratio, measured in per cent, refers to the amount of time the pulsator is open and closed in one minute.

It is often thought that the faster the pulsator operates, the faster the cow milks. This is not necessarily true. Excessive speed may have adverse effects. The rate of milking depends primarily on pulsation ratio, vacuum level and type of inflation. If the ratio is 50:50 and the rate of the pulsator is 50 or 75 pulsations per minute, the ratio is still the same. However, if the ratio is 75:25, the pulsator is open (milking) 75 per cent of the time and closed (massaging) 25 per cent of the time.

Each milking machine is designed to keep all these factors in balance. Follow the manufacturer's recommendations.

There are several types of pulsators. *Master* pulsators operate two or more units simultaneously. *Unit* pulsators operate a single unit and may be fastened to the milking unit or attached to the vacuum line. Both may operate on either uniform or alternating pulsation. In uniform pulsation the opening and closing action occurs simultaneously on all four teat cups. In alternating pulsation two teat cups are open while two are closed.

Unit pulsators may be dependent and independent. Dependent pulsators are either electromagnetic, electropneumatic, or controlled by an electromechanism; they are subject to electrical failures but generally are more dependable and efficient. Independent or pneumatic pulsators are air driven and depend on slides covering air ports to open and close the pulsator. Their speed varies with vacuum, temperature, and the type of oil used; they are satisfactory but require much maintenance and are subject to wear and plugged ports.

THE MILKING UNIT

The milking unit consists of inflations, shells, receptacle for collecting milk, milk hoses, and air hoses.

INFLATIONS

The basic function of inflations or teat cup liners is to enclose the teat providing the enclosed system, and to open and close providing the milking-massage action. Nearly all liners available in South Dakota are molded. These may be wide bore (greater than ¾ inch inside diameter) or narrow bore (less than ¾ inch inside diameter).

The narrow bore liner generally is superior to a large bore liner in maintaining udder health. The larger bore liners have more inside diameter which creates a ballooning action on the teat and causes excessive stretching. In addition, as milking progresses large bore liners tend to crawl higher than narrow liners; this action can close the opening between the teat cavity and the udder, shutting off milk flow.

Most inflations are made either of natural or synthetic rubber. Natural rubber is more resilient than synthetic, but it is affected more rapidly by milk fat. Synthetic inflations last longer and flex thousands of times without taking a permanent set.

TEAT CUP SHELL

The teat cup shell is made of stainless steel and should be properly fitted to the size of the liner. A large shell used with a narrow bore liner will cause improper distribution of air and vacuum between the liner and the shell. Improper liner action can cause damage to the teat.

RECEPTACLE FOR MILK

The receptacle to hold the milk may be either a suspension- or claw-type unit. On a suspension pail-type unit the milk flows directly from the inflation into the pail. Advantages: adjustable weight distribution and line of pull, easy individual quarter attention, positive vacuum shut-off for each teat cup that drops off, good vacuum stability, and short milk movement. Disadvantage of bucket milkers: they may become over-filled with milk permitting the milk to be drawn into the vacuum line; this accumulation can lead to line blockage.

A claw-type unit may be used with a pail or pipeline system. The inflations are attached to the claw and milk flows through it. The milk then is forced by air from the claw through a hose to either a pail or a pipeline. These units offer the advantage of high labor efficiency because they are simple to adjust, lightweight, easy to use on low-uddered cows, and easy to clean. Disadvantages: more frequent teat cup droppage unless supported and difficulty in giving attention to individual quarters. There is some evidence that alternating pulsation with claw-type units will maintain a more stable vacuum.

Both claw-type and suspension-type units will do an excellent milking job if the vacuum system is adequate, properly installed, and the equipment is designed for the milk flow characteristics from the four teat cups.

MILK AND AIR HOSES

Milk hoses are of synthetic rubber or clear plastic. Rubber has better flexibility and longer life, but plastic is popular because it offers desirable visibility. Plastics may take a permanent "set" and may crack where repeatedly slipped onto a claw or pipeline nipple. Consequently, many dairymen buy extra-long air hoses knowing they will need to trim the ends frequently. Milk hose diameter and length should be as recommended by the manufacturer. Looping excess hose can cause trouble. A larger hose diameter will not necessarily improve flow characteristics or vacuum stability.

Pulsator or air hoses are either single or duplex, depending on the type of pulsator. They should be of good quality rubber for flexibility and good sealing ability around the nipples. The same recommendations apply to both air hoses and milk hoses.

THE MILK FLOW SYSTEM (Milk Line)

The milk-flow system refers to the movement of milk through a line. Since milk can not be moved under vacuum alone, a means must be provided to push the milk through the hose or pipeline. This is accomplished by providing an air hole in the unit. Air entering the enclosed system pushes or forces milk in the milk hose or pipeline to a receiver where the air is removed.

It is important that size of the air hole comply with manufacturer's recommendations. Take special precautions to prevent plugging the hole. Excessive air admittance will cause rancidity problems. Inadequate air admittance will cause slower milk flow and vacuum instability.

The diameter of the milk line depends on the number of units in use and the anticipated milk flow. Standard lines are either 1½-inches outside diameter stainless steel tubing or 1½-inches inside diameter heat resistant glass pipe. A 1½-inch milk line is adequate for three units. When using four or more units in an around-the-barn pipeline or in a parlor, use a 2-inch milk line to maintain vacuum stability and adequate milk movement.

Too many units or too small a line reduces vacuum stability at the end of the teat. Provide a line slope of 1½ inches per 10 feet of milk line. This conveys the milk primarily by gravity flow in the bottom portion of the milk line.

REMEMBER . . .

These four basic milking machine components, although separate, must function together. Malfunction by any one component reduces the efficiency of the total system. Knowing your system can improve its performance resulting in better cow milk, better health, and better production. Have your milking system checked at least once a year.

Ask for these dairy production fact sheets:

- FS 403 "Milk Production"
- FS 405 "Screening Tests for Abnormal Milk"
- FS 406 "Urea for Dairy Cattle"

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