22) THE MILKING MACHINE

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The basic layouts of milking machines include:

- Milk collection in a bucket placed next to the cow;
- Pipeline systems in which cows are milked in a cowshed and the milk flows to a central collection tank;
- Parlor systems in which all the equipment is centralized and cows come to the parlor for milking.

Despite the great diversity of milking installations, milking machines work on the same basic principle: milk is collected from the cow by vacuum (suction). Figure 1 illustrates the basic components of all milking machines; these include:

- A vacuum system: vacuum pump and reserve tank, vacuum regulator, pipelines and long pulse tube(s) forming an enclosed space;
- Pulsators that alter the vacuum level around the teat so that milking occurs without fluid congestion and edema of the teat tissues;
- Milking units or cluster: the assembly of four teatcups connected to a claw and mounted with a valve that admits and cuts off the vacuum to the unit;
- A milk removal system that transport the milk away from the milking unit toward a storage unit: the milk tube and receiver (bucket, recorder jar, milk pipelines, milk pump, etc.).

All these components require a high degree of coordination for the milking machine to function properly.

VACUUM SYSTEM

Vacuum pump

The vacuum pump evacuates air from the pipelines and the milking units to create the vacuum needed to milk cows. Most current machines also use the vacuum to transport milk to a receiver jar (or directly to the bulk tank, itself under vacuum), and to wash the milking equipment.

To prevent solid and liquid material from being drawn into the pump, an interceptor must be fitted on the main vacuum line adjacent to the pump.

Creating and measuring vacuum

Vacuum means pressure below the normal atmospheric pressure. When the vacuum pump is turned on, the air is evacuated causing a drop in air pressure inside the pipelines and the milking units (an enclosed space). The difference between the air pressure outside the pipeline and the (negative) air pressure inside the pipeline is called the vacuum level.

A mercury manometer may be used to measure the level of vacuum (Figure 2). This instrument is made of a “U-shaped” tube partially filled with mercury (Hg). One end of the tube is connected to the pipeline and the other end remains open to the outside (atmospheric) pressure. When the vacuum pump is “off,” the atmospheric

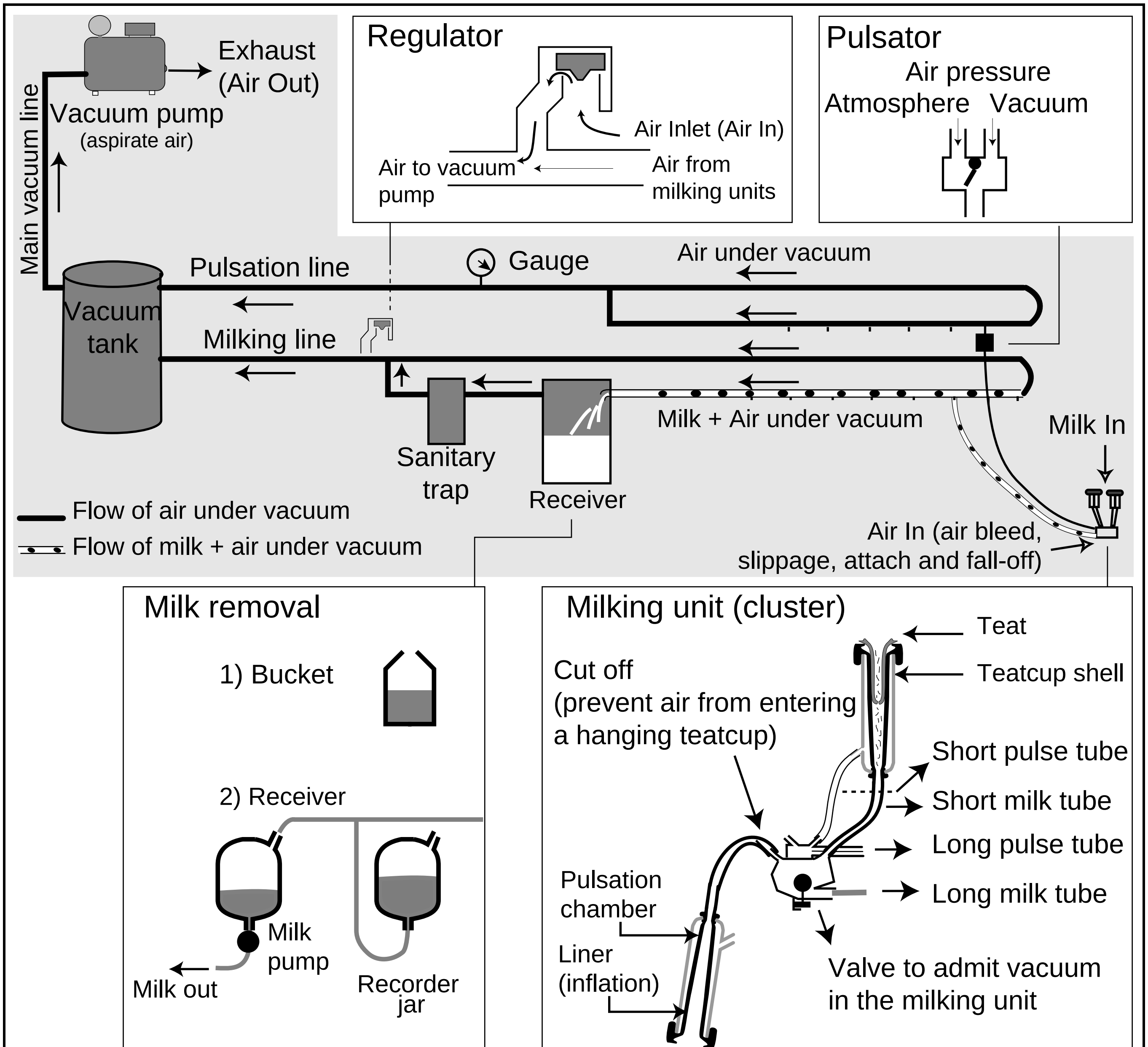

Figure 1: Basic components of milking machines

pressure acts both inside and outside the pipeline and the level of mercury is the same in both arms of the manometer. However, when the vacuum pump is turned on, the air pressure inside the pipeline becomes lower than outside. One can think of the outside atmospheric pressure "pushing" the mercury down and the vacuum on the inside "pulling" the mercury up. The difference in level of mercury in each arm is the level of vacuum. Although "mm of mercury" is still commonly used, the "Kilo Pascal (Kpa)" is now the official international standard to measure the vacuum level of milking equipment (1 mm Hg = 0.1333 Kpa).

Vacuum regulator (controller) and gauge

The function of the regulator is to admit air into the system to keep the vacuum at the recommended level. Normally, the vacuum pump creates a level of vacuum greater than needed in the milking unit. The regulator senses the changes in vacuum (due to leaks, attaching and removing the milking units, slippage, etc.) and controls the amount of air admitted into the vacuum system to maintain the desired vacuum level within a very narrow range. The controller may be a weighted diaphragm or spring-operated device (Figure 2). To operate properly, it must be placed at the correct location according to the milking system (bucket, pipelines or parlor). The vacuum gauge should be used to detect abnormal levels and fluctuations in vacuum that may come from serious air leaks, a dirty regulator, slipping vacuum pump belts, etc.

PULSATOR

The pulsator is a simple valve that admits air and vacuum alternatively in the pulsation chamber of a teatcup. The action of the teatcups of a milking unit is made possible by the pulsator.

Pulsators may be activated by vacuum or an electrical signal from a pulsator controller to give a frequency of 45 to 65 cycles per minute (pulsation rate). Pulsators may have simultaneous or alternating actions. The pulsation is simultaneous when all four pulsation chambers of the milking unit are in the same position at the same time (all four at the milking phase at the same time, and all four in the massaging phase at the same time). With the alternating action, two of the teatcups are milking while the other two are massaging. Milk flows more regularly and the fluctuations in vacuum are smaller with alternate pulsation; however, the total number of vacuum fluctuations is doubled compared to a simultaneous pulsation system.

CLUSTER (MILKING UNIT)

The parts of a milking unit are illustrated in Figure 1 and a detailed description of the action of the teatcups is presented in the *Dairy Essential* called “Principles of Milking” (number 3 in the “Lactation and Milking” series). The liner inside the teatcups of the milking unit is the only part of the machine that comes in contact with the udder of the cow. Thus the weight of the unit is usually adjusted to the vacuum

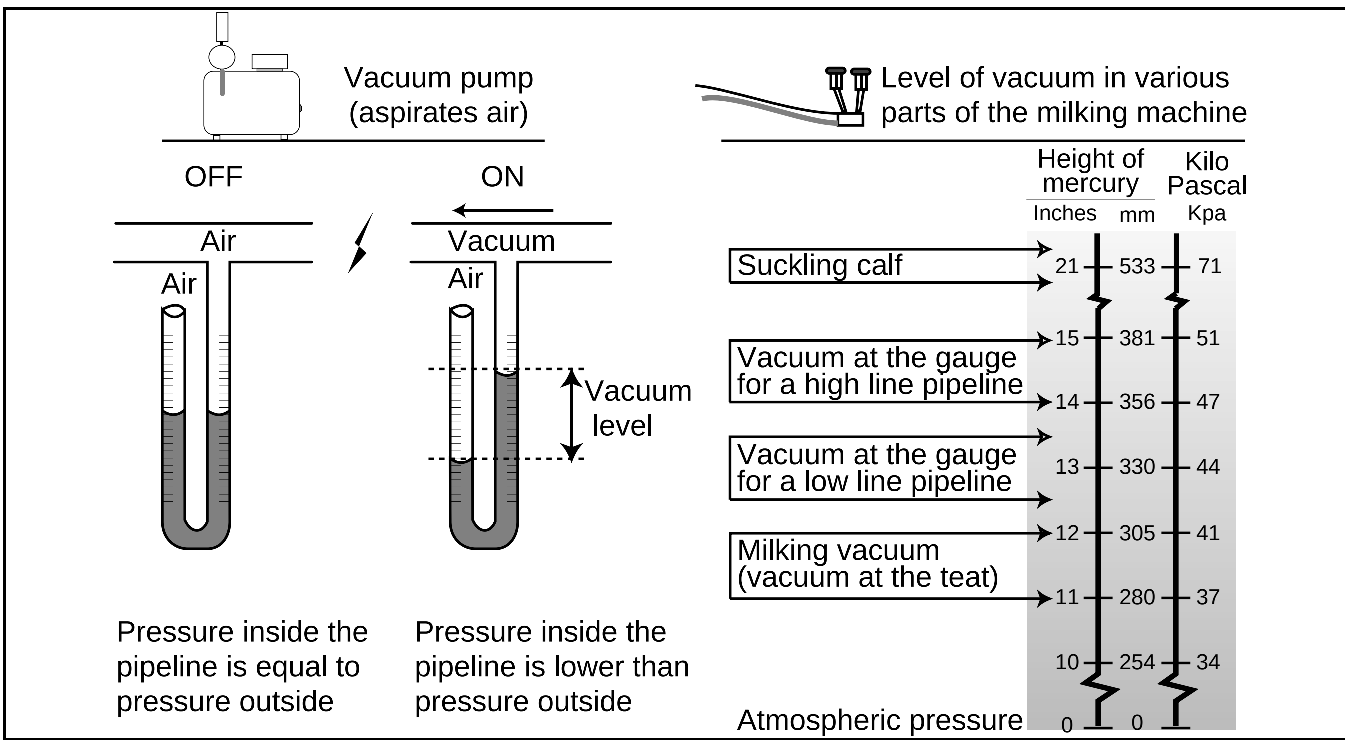

Figure 2: The vacuum level is measured as the height of a column of mercury (or Kilo Pascal) when air is aspirated away from an enclosed space.

level to provide the desired tension on the teat to allow proper positioning and adequate milking action. If the vacuum level inside the unit is too high or the unit is too light, the following may occur:

- The unit "creeps up" and tends to pinch the area where the teat meets the udder. Milk flow stops and the operator must pull down the unit to completely milk out the cow;
- Teat lesions are more likely, making the cow more susceptible to mastitis;
- Teat congestion increases, which tends to decrease the size of the teat canal and the speed of milking.

When the vacuum is too low or when the milking unit is too heavy the following may occur:

- The milking unit falls off easily;
- A weak seal between the teat and the liner leads to more frequent slippage and admission of air in the unit, creating undesired vacuum fluctuations and greater risk of spreading mastitis;
- The speed of milking is reduced.

During milking, the flow rate may range from 2 to 5 kg of milk / minute for a period of two to eight minutes depending on milk yield. Thus the design of the cluster is important to ensure that milk flow is not restricted. In addition, good visibility of milk flow is important because it allows the operator to make sure the unit is properly adjusted at the beginning of milking and to identify the end of milking easily.

The four liners of a milking unit contract and dilate many times during a single milking. As they wear out, they become creviced, stretched and stiff (lose their elasticity) and react more slowly to changes in pressure. Over-used liners decrease milking speed and increase the risk of spreading mastitis. Thus they should be replaced periodically. A liner's life span depends on many factors and it is very important to follow the manufacturer's guidelines as to frequency of replacement.

MILK REMOVAL SYSTEM

Once the milk has been collected into the milking unit, it must be transported away. The "transport system" must be properly designed such that milk flows quickly without flooding the line or backing up through the milking unit.

A small air admission hole in the claw helps to stabilize the vacuum in the teatcup during milking and to carry the milk away. Milk and air flow together in the milk line (which is under vacuum) until separated in a receiver jar (Figure 2). Without proper air admission, the vacuum level may fluctuate considerably in the milking unit, in part because of the weight of milk in the long milk tube. The air to milk ratio becomes especially important where milk has to be elevated from the claw to a high pipeline (highline system). When a column of milk is elevated in a vacuum tube one meter long, the vacuum level in the milking unit is reduced by about 10 Kpa (75 mm of Hg). The introduction of air into the milk line "breaks" the column of milk and facilitates the movement of the mixture of air and milk in the long tube. A milking system in which milk flows down from the cluster into the milk line (lowline system) is a better choice than having it flow up to an elevated line (highline system).