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N. A. Jorgensen

E. J. Kleen

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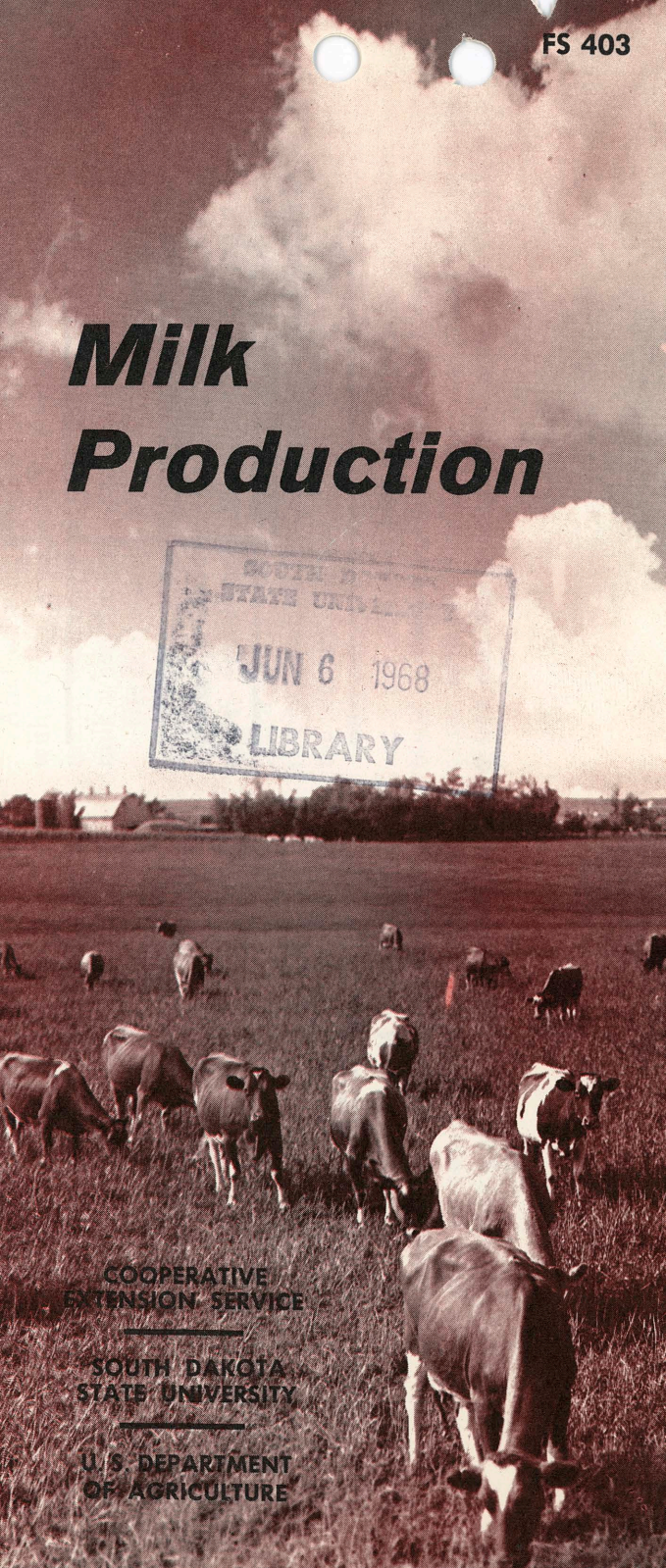


COOPERATIVE EXTENSION SERVICE

SOUTH DAKOTA STATE UNIVERSITY

U. S. DEPARTMENT OF AGRICULTURE

Milk Production

by N. A. JORGENSEN, assistant professor of dairy science,
and E. J. KLEEN, assistant extension dairyman

Milking, properly done, is a highly skilled job. Cows may be fed for maximum production, bred to produce at high levels, and be in good health, and yet, they will not produce at their best if you do not do a good job of milking. You need to understand how a cow produces milk before you can apply the proper procedures in the milking routine.

THE UDDER

The udder is a skin gland. It is not directly connected with the body cavity except through the inguinal canal. This canal forms a passage for blood vessels, lymph vessels, and nerves.

Since the udder of a mature cow may weigh from 25 to 75 pounds and may hold 60 or more pounds of milk, the total weight of the udder and the milk it contains may exceed 150 pounds. Udder weight varies from cow to cow depending on stage of lactation; size; amount of secreting tissue; and amount of scar, connective, and fat tissue. Udder size alone is not a good indication of milk secreting ability.

You can't look inside and check udder quality, so outside appearance and feel are the best indicators for estimating production capacity. Look for these characteristics:

- A wide udder extending well forward and closely attached in front.
- Rear attachment high and wide.
- Rear udder extending full width between—not in front of—the hind legs.
- Udder floor reasonably level.
- Quarters uniformly and symmetrically developed.
- Teats uniform in size, length, and placement; free of lumps, warts and extra openings.

A soft, pliable udder is important. An udder that shrinks away and becomes flabby after milking indicates the presence of much secretory tissue. A hard, meaty udder contains a large amount of fatty and fibrous tissue and little milk-secreting tissue.

Proper massage before each milking will aid in detecting abnormal tissue and allow early treatment of injury. Once milk-secreting tissue is damaged and scar tissue develops, it will never secrete milk again. Appearance and feel before and after milking tell much about the udder's producing ability.

A strongly attached udder contributes to the cow's maximum life-time productivity. Well-attached udders are less susceptible to injury and infections—the forerunners of mastitis.

The udder is suspended from the cow's body wall by the *median* and *lateral suspensory ligaments*, as well as by connective tissue, deep side tissue, and skin. The median suspensory ligament separates the udder into right and left halves. The lateral suspensory ligaments form a fibrous layer around the udder and join the median ligament at the base of the udder. Together the ligaments form a sling which holds and supports the udder (See Figure 1.)

The lateral suspensory ligaments are chiefly fibrous; the median suspensory ligaments are more elastic. As the udder fills with milk, the median suspensory ligaments stretch and may allow the teats to protrude outward.

A "breaking away" of the udder from the body occurs when the supporting ligaments become permanently lengthened resulting in a pendulous udder. Either problem—protruding teats or a pendulous

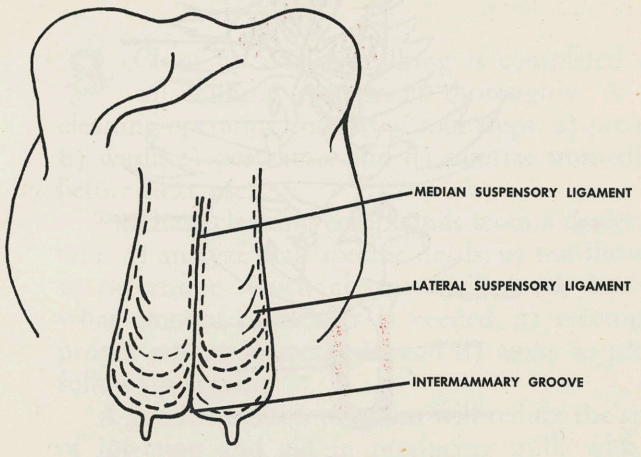


Figure 1. Supporting Structure

udder—is serious since either or both make machine milking difficult. Pendulous udders also are more susceptible to injury and infection.

TEATS

Consider adaptability of the cow's udder and teats to machine milking when selecting herd replacements. Teats placed squarely on the udder and hanging vertically aid efficient machine milking. Long, large teats are injured easily and are difficult to machine milk. Extra teats (supernumerary) should be removed when a heifer is a few weeks old; they may interfere with functional teats or mammary tissue, and they can form a natural opening for bacteria to enter and cause infection—mastitis.

Abnormal teats can be a source of trouble. The wall of the teat contains many arteries and veins. One-way valves in the veins require massage to aid movement of the blood out of the teats and back into the circulatory system. Thus, the alternating vacuum-massage cycles of the milking machine prevent the congestion of blood at the end of the teat. Injury to teats can occur if blood doesn't move out of the teat during the massage phase.

Inside the Udder

GLANDS

The cow's udder consists of four separate glands. The left and right halves are separated by the median suspensory ligament. The front and rear quarters are separated by a fine membrane. Since the udder follows the contour of the cow's body wall, the rear quarters are deeper than the front. On the average, 60 per cent of the milk is obtained from the rear quarters, 40 per cent from the front.

MILK SECRETION

The basic milk-secreting unit of the udder is the *alveolus*. The entire arrangement of the udder centers around billions of alveoli. (See Figure 2.)

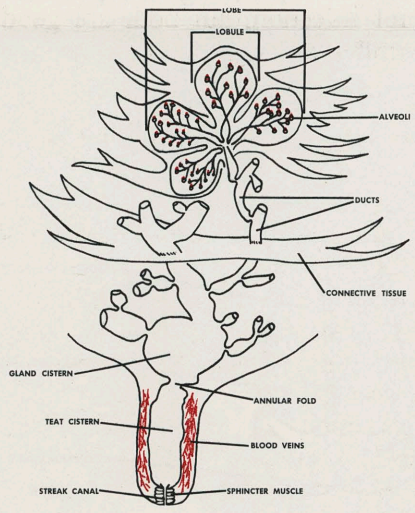


Figure 2. Udder Structure

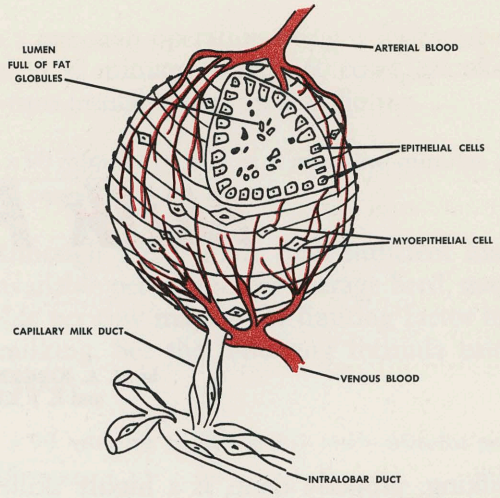


Figure 3. The Alveolus, Milk Manufacturing Cell

Each alveolus has a lining of *epithelial cells*. (See Figure 3.) A network of fine capillaries carries blood containing materials such as acetic acid, amino acids, glucose, proteins, vitamins, and minerals to the epithelial cells where they are manufactured into milk.

Milk formation is a continuous process. During a twelve-hour interval production is rather uniform. The rate of formation slows, however, as the interval is lengthened. As the alveolus fills with milk and stretches, pressure within the udder increases causing blood flow in the capillaries around the alveoli to slow down. The milk manufacturing process virtually stops as the blood supply is reduced. It is estimated that 300 to 500 pounds of blood must flow through the udder to supply the materials for one pound of milk.

Cows milked on ten and fourteen-hour intervals will produce more milk during the long interval, but the secretion rate per hour will be less. For maximum milk production during a 24-hour period, keep the milking intervals uniform. This is especially important for high-producing cows. Eleven- thirteen-hour intervals can be used with little difference in production rates, but for high producers, avoid intervals longer than thirteen hours.

THE DUCT SYSTEM

The alveoli are connected to a duct system which provides passage for the milk. The duct system is like the branches of a tree. The small ducts at the top of the udder open into larger and larger ducts until they finally empty into a single, large opening in each quarter called the *gland cistern*. Capacity of the gland cistern is about one pint.

A structure called the *annular fold* separates the gland cistern from the *teat cistern*. As the gland shrinks near the end of milking, the teat cup "creeps" up on the teat and presses against the annular fold. This stops milk flow. Holding down gently on the

teat cup assembly and massaging the udder at this time aids in removing all milk present in the ducts and gland cistern.

The opening at the end of the teat is called the *teat canal* or streak canal. This canal is ¼ to ½ inch long and is surrounded by a *sphincter muscle* which prevents out-flow and leakage of milk between milkings and guards against mastitis-producing bacteria entering the gland. The tighter the sphincter muscle, the smaller the teat opening; result: a slow-milking cow. If, on the other hand, the sphincter muscle is too weak, milk will leak from the teat because of pressure within the gland and that quarter will be more susceptible to mastitis.

MILK "LET DOWN"

When a cow is properly stimulated by washing and massaging the udder, nerves in the udder send a message to the brain, which in turn sends a signal to the pituitary gland, which in turn secretes the milk-let-down hormone, *oxytocin*. (See Figure 4.) The blood stream carries the oxytocin to the muscle fibers *(myoepithelial cells)* that surround each alveolus. The action of the oxytocin causes the muscles to contract; this forces milk out of the alveoli into the large ducts and gland cistern.

Before milking, pressure equivalent within the gland cistern from accumulation of milk can vary from 25 to 35 millimeters of mercury. Proper stimulation at milking time nearly doubles the pressure within one minute after stimulation.

Milk production may be reduced up to 35 per cent during a single milking or lactation if proper stimulation is not practiced. It has been estimated that only 40 per cent of the milk obtained at a milking is present in the cisterns and large ducts, whereas 60 per cent is held in the small ducts and alveoli.

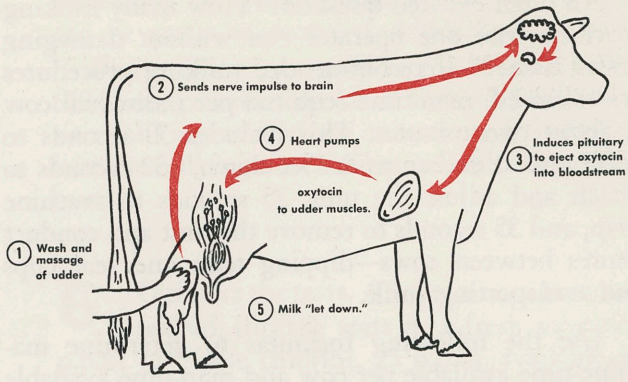
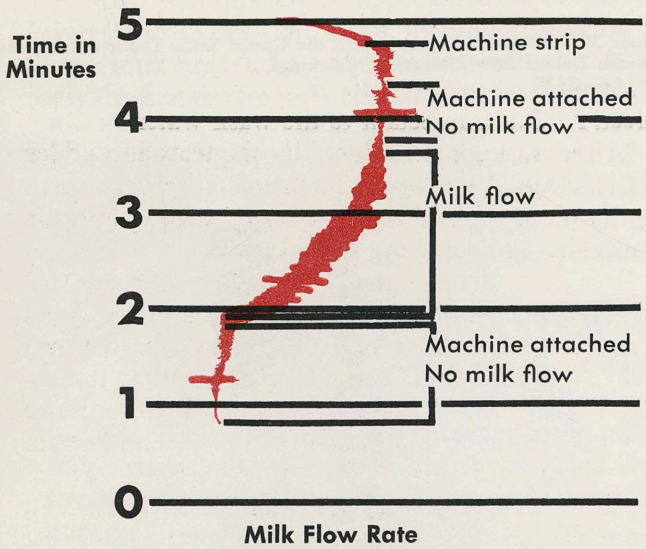


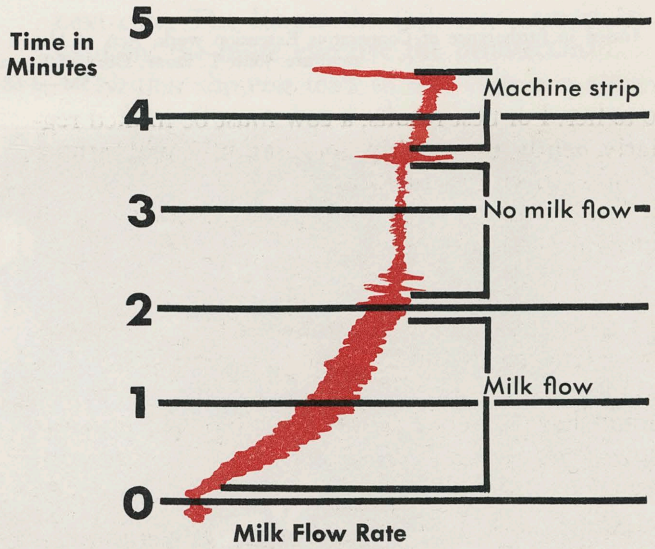
Figure 4. Milk "Let Down"

The graph in Figure 5. illustrates milk flow from the same cow during two different milkings. The graph on the left (5a) shows milk flow when no stimulation was applied; the graph on the right (5b) shows milk flow with proper stimulation. The space between each horizontal line represents one minute. The angle of the graph marker measures the rate of milk flow. Where the marker is a vertical line, the machine is attached but milk flow either had not yet begun or had stopped.

Read the graph from the bottom up (5a). For approximately the first one minute there was very little milk flow. The action of the liners was creating a stimulus. During the second minute the milk flow rate was the heaviest (angularity of lines). During



5a. Without stimulation, 18 lbs., 4 minutes



5b. With stimulation, 31 lbs., 4½ minutes

Figure 5. Milk Flow Rate With and Without Stimulation

the third and fourth minutes a small amount of milk was removed at a very slow rate. In the total four minutes of machine time, 18 pounds of milk were removed.

When (5b) the same cow was properly stimulated, milk flow was immediate. Nearly 31 pounds of milk were removed in two minutes. However, the milking unit was left on for another two and a half minutes. No milk was flowing except for the last half minute when machine stripping was taking place. Although a total of 31 pounds of milk was removed in four and a half minutes, the milk flow—including machine stripping—took only two and a half minutes.

More milk—42 per cent in this case—but 25 to 35 per cent on the average—can be obtained per day or per lactation by properly stimulating "let down."

Milking Procedures

Milking is a twice-daily occurrence and, because cows are creatures of habit, a certain percentage of milk in any udder may be removed by nearly any management practice. However, healthy cows and maximum milk yields in the shortest possible time should be the goals of everyone who milks, and it has been proved that the amount of milk obtained from a cow is directly correlated to the milking procedures of the man who milks her.

Outlined here are those practices which have been demonstrated through research to be the most effective in removing the most milk from the udder in the shortest tme.

A good milking routine will do the following:

1. Increase milk production.
2. Produce a higher quality product.
3. Increase the efficiency of milking.
4. Reduce the spread of disease-causing organisms.

Full cooperation of the cow during milking is an absolute essential. She is a creature of habit, and breaking routine is probably the worst thing you can do to her. For best results, a cow must be milked regularly, gently, thoroughly, and promptly, with proper attention given to sanitation.

The following steps are recommended for an efficient milking procedure:

1 **Assemble and disinfect the milking equipment.** Use the manufacturer's operations manual to assemble the equipment. With a pipeline system you should have a bucket milking unit to use on cows showing signs of mastitis or on cows which have been treated for mastitis.

Disinfect all milking equipment with a solution of 200 p.p.m. available chlorine, 25 p.p.m. available iodine, or some other sanitizer (quaternary ammonium compounds, acid wetting agent). Follow the manufacture's directions in preparing the disinfecting solution—using more than the directions call for is costly and it can be harmful.

Check the operation of all equipment and adjust as needed before beginning to milk.

2 **Prepare the cow for milking.** At milking time a cow links several associations to milk "let down." Many cows associate "let down" with anything that occurs frequently at milking time—walking into the barn or parlor, hearing the sound of a vacuum pump or a radio, or the act of feeding. These are called *secondary stimuli.* Approximately 30 to 40 millimeters of mercury pressure may be obtained in the udder with secondary stimuli. The pressure may be sufficient to remove the milk, but under most circumstances, by the time the unit is attached to the cow the peak of preliminary "let down"—if it occurs at all—is passed and no great benifit is realized.

To obtain maximum milk in the shortest possible time, the cow must be conditioned to respond to a *primary stimuli:* massaging the teats and udder for 30 seconds with a single service paper towel soaked in warm water (100° to 110° F.) produces an instant effect. Add a disinfectant to the wash water.

After washing the udder, dry the teats and udder with a clean, dry towel. This prevents water contaminated with dirt and bacteria from running into the milk when the teat cups are attached.

Use of the strip cup is probably the most omitted good management practice during preparation. There are three good reasons for using a strip cup. Removal of 2 to 3 squirts of milk into a strip cup allow the operator to: a) check for abnormal milk; b) remove fore milk which is high in bacteria count; and c) aid the primary stimulus.

Keep the cow calm. Excitement or irritation will cause the hormone *adrenalin* to be released into the blood stream. This hormone counteracts the action of the milk-let-down hormone and causes milk to be held back. This means reduced yields.

3 **Attach and adjust the machine.** Attach the machine one minute after stimulation in order to take full advantage of the conditions which have been set up for maximum milk removal. The oxytocin effect does not reach the udder until about one minute after the stimulating action is completed, and it only lasts from three to eight minutes. Since a cow can not be restimulated to "let down" her milk for about two hours, failure to attach the unit at the proper time will result in reduced milk yields. Yields will be little different than if no stimuli is used.

Take 20 to 30 seconds to adjust the unit. Adjust a suspended unit so it is hanging level and there is a slight tension on the teats. Attach claw-type units so there are no loops in the hose from the claw to the milk receiver. A slight tension may be applied to the teats by proper adjustment of the pail.

Remember . . . do not attach the machine until proper stimulation has been performed—attaching the unit before milk "let down" has occurred can injure the teats.

4 **Machine strip.** As milk is removed from the udder the ducts tend to relax or sag downward and up to 20 per cent of the milk yield may be trapped. As the lower part of the udder becomes flabby, pulling downward on the teat cup assembly prevents the teat cup from sealing off the opening between the teat and gland cistern. It also tilts the ducts so milk will drain out while the operator massages the udder. Proper machine stripping may require about 25 seconds. This depends on the degree of stimulation applied before attaching the machine and the manner in which the machine was attached.

Milk is composed of approximately 87 per cent water and 13 per cent solids, including proteins, lactose (milk sugar), fat, vitamins, and minerals. Normally the first drawn milk contains less fat than the last. For example, a cow with an average milk fat test of 4.3 per cent: the first pound of milk may test 1.5 per cent fat, but the last pound removed may test 11.5 per cent. So, for maximum milk fat test, obtain all milk possible. Incomplete milking also reduces persistency and length of lactation.

5 **Remove the machine as soon as milk flow stops.** Break the vacuum by allowing air to enter the teat cup. If the vacuum is not eliminated, the pulling action required to disengage the machine will create stress on the end of the teat and may cause permanent damage.

Normally, easy-milking cows, as well as two- and three-year old cows, should milk out in two and a half to three minutes, older cows in three to four minutes. Very high-producing or hard-milking cows will require more time. But, **do not over-milk.** Failure to remove the milking machine at the proper time can be costly in terms of udder health and labor.

Remember . . . you milk each cow on an average of 610 times per year. At labor costs of $1.00 per hour, over-milking a cow one minute each milking will increase milking time ten hours or $10.00 per year per cow.

6 **Disinfect the teats.** After teat cups have been removed, dip the teats in a fresh solution (200 p.p.m. available chlorine, 25 p.p.m. available iodine, or 200 p.p.m. quaternary-ammonium compound). This will remove milk from the end of the teat and prevent invasion by bacteria. Disinfecting will reduce the spread of infection, and will aid in the control of fly problems. Be sure to follow the manufacturer's recommendations, when preparing disinfectant solutions.

If there is danger of teats freezing, massage lightly with a dry cloth or paper towel to remove any milk accumulation on the end of the teat and to stimulate blood circulation.

7 **Disinfect teat cups.** Sanitize the inflations by rinsing first in clear water, then in disinfectant. To insure maximum contact of disinfectant with the teat cup liner, dip two teat cups at one time. This prevents air blockage in the liner. If the teat cups are placed in disinfectant immediately, the droplets of milk will soon make the solution ineffective.

By dipping the inflations most of the bacteria will be removed that otherwise would be carried to the next cow. The longer the inflations remain in the solution, the more effective the disinfectant.

Neither dipping teats or teat cups is a complete cure for infection, but both are good steps toward total sanitation.

8 **Clean up.** When milking is completed clean all milking equipment thoroughly. A good cleaning operation consists of four steps: a) pre-rinse, b) wash, c) post-rinse, and d) sanitize immediately before next use.

Purchase cleaning compounds from a dealer who will: a) analyze your specific needs, b) test the water to determine which cleaners will work best and what amount of cleaner is needed, c) recommend proper sanitation methods, and d) agree to provide follow-up service.

A good sanitation program will reduce the spread of infection and aid in producing milk with low bacteria count.

NUMBER OF MILKING UNITS

An often debated question: "How many milking machines can one operator run without damaging udder tissue?" If recommended milking procedures are followed, man-time required per individual cow is about two minutes. This includes 30 seconds to wash and stimulate milk "let down," 30 seconds to attach and adjust the unit, 25 seconds to machine strip, and 35 seconds to remove the unit and conduct chores between cows—dipping teats and teat cups and transporting milk.

Use the following formulas to determine machine-time available per cow and man-time available per cow in an individual operation:

$$\text{Machine-time available per cow} = \frac{\text{Number units} \times \text{total milking time in minutes}}{\text{Number cows milked}}$$

$$\text{Man-time available per cow} = \frac{\text{Number men} \times \text{total milking time in minutes}}{\text{Number cows milked}}$$

In a one-man operation using a four-unit system requiring 90 minutes to milk 60 cows, calculate machine-time available per cow as follows:

$$\frac{4 \text{ units} \times 90 \text{ minutes}}{60 \text{ cows}} = \frac{360}{6} = 6 \text{ machine-minutes per cow}$$

Although this is more than sufficient machine-time available per cow in the average herd, man-time available per cow may be the limiting factor to good cow milking. See the following formula using the above data:

$$\frac{1 \text{ man} \times 90 \text{ minutes}}{60 \text{ cows}} = \frac{90}{60} = 1\tfrac{1}{2} \text{ man-minutes per cow}$$

This indicates that there is not enough man-time in a one-operator, four machine-unit system to do a proper job of milking if recommended milking procedures are followed.

Research indicates that if recommended milking procedures are to be followed, one operator can handle no more than two units in a bucket-type system, no more than three units in a pipeline (barn or parlor) system.

Ask for these dairy production fact sheets:

FS 404 "The Milking Machine"
FS 405 "Screening Tests for Abnormal Milk"
FS 406 "Urea for Dairy Cattle"

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