FOREWORD

Milking Machine Management, volume 2, is the seventh in a series of management manuals published by Veepro Holland. In Milking Machine Management, volume 1, the milking machine installation and its various components were described. The present manual, Volume 2, deals with the testing and maintenance of milking machines and the storage and cooling of milk.

Through these manuals Veepro Holland aims to provide you with useful management information. Dairy cattle worldwide need to be managed well to utilise their potential to full extent.

No single booklet can cover every subject as diverse and complex as dairying. Nor will probably everyone associated with dairying agree on all points covered in one publication. But we of Veepro Holland believe the combination of this manual and other publications on the subject may broaden your knowledge about milking machines as well as cooling and storage of milk, and will subsequently contribute to a healthy and highly productive herd.

Veepro Holland is indebted to those who contributed to this manual, particularly Ing. Wim Rossing of the Institute of Agricultural Engineering (IMAG-DLO) of Wageningen and Ing. Kees de Koning of the National Reference Centre for Livestock Production (IKC) of the Ministry of Agriculture, Nature Management and Fisheries at Lelystad for their constructive criticism.

We would like to thank the IPC-Livestock/Dairy Training Centre 'Friesland' at Oenkerk for their valuable assistance in the preparation of this manual.

Many thanks also to those associations and publishers who permitted us to use various data and illustrations.

VEEPRO HOLLAND
Milk provided to consumers should be of the highest possible quality. Therefore, it is necessary that milk of the highest quality be produced and that quality be maintained throughout, because it cannot be improved once the milk has left the udder. Almost all bacteriological milk quality problems result from either inadequate cleaning and disinfection or inadequate storage and cooling at the dairy farm. The cleaning and disinfection of milking equipment is described in detail in the Proper Milking Management manual.

INTRODUCTION

Milk storage and cooling facilities, purchased from a dealer who is able to provide expert installation and after-sales services. Furthermore, the milking machine is without any doubt the most-used equipment at a dairy farm. Twice daily throughout the year the milking machine is in operation, so it requires testing and maintenance to ensure its proper functioning, on which the success of machine milking systems mainly depends. Please consult the Milking Machine Management manual, volume 1, and the Proper Milking Management manual for more information. Nevertheless, there is plenty of room for further improvement. Following a programme of routine testing can bring great benefits to you through elimination of unnecessary service calls and minimization of the chance of a major breakdown.

Good cooling and storage of milk is one of the most important factors in maintaining milk quality. As herd sizes grow and milk production yields increase, it is vital to describe the cooling capabilities of various milk cooling systems before buying and installing any equipment. The proper installation of milk storage and cooling facilities is critical to your dairy business. Therefore, it is important to invest in good sound storage and cooling facilities are essential for delivering high-quality milk.
THE TESTING OF THE MILKING MACHINE

The dairy farmer should know not only how his milking machine works, but also what regular inspection and servicing the installation needs to keep it performing at optimal efficiency. Prevention is better than cure, because a break-down always takes place during milking, which causes great inconvenience.

Why testing
All milking machines should be tested to assess whether they are in good working order and conform to the guidelines of the International Standard Organisation (ISO) for milking machines. Milking machines that are incorrectly installed or in faulty working order will quickly irritate the sensitive teats and udder tissue, and may cause lower milk production and probably mastitis in the long run. So faults adversely affecting milking efficiency should be detected by regular tests between and during milkings. These checks, together with the periodic maintenance will practically eliminate the risk of unexpected break-downs.

Testing procedure
The milking machine should be checked thoroughly by testing all parts at least once a year and more complicated components even twice. The testing must be done by a qualified technician. The worn-out parts, such as liners, should be replaced in time in order to keep the milking machine in optimal working condition. The technician should discuss the test results and advise the dairy farmer which necessary action should be taken. For future reference the test results should be listed on a test report form, together with a record of replaced components.

The service history of the milking machine is invaluable to the dairy farmer during the life-time of the various components of the installation.

The milking machine test report must contain:

- a complete measuring and condition statement of the whole installation;
- advice for adjustments and repair, and replacement of different parts.
What has to be tested
All parts and components of the milking machine installation should be tested. These include:

- the working vacuum level at static level and in full use;
- the air consumption of the various components and the vacuum reserve capacity of the vacuum pump to maintain always the correct vacuum level;
- the air resistance in the vacuum pipelines;
- the pulsation characteristics;
- the state of maintenance of all other components.

be temporary installed for measuring the air consumption of the various components, such as vacuum reserve, air resistance, and the difference in vacuum levels during the operation of the installation. During the test all values should be filled in on the milking machine test form and be compared with the prescribed standards.

Testing the working vacuum level
The test procedure should include a test to determine if the milking installation is capable of maintaining the correct vacuum level when all milking equipment is in full use and provides an adequate vacuum reserve at all times. Be sure that the vacuum required is reached a few seconds after the vacuum pump has been started by observing the vacuum gauge. Then the working of the installation with one unit is compared with all units in operation.

During testing, continuously compare the reading of the permanent vacuum gauge with the calibrated control vacuum gauge. The vacuum is expressed in kPa. Please consult table 1 in Milking Machine Management, volume 1, for the conversion for units of pressure. The acceptable range for the operating vacuum level for most machine milking systems is 40-50 kPa. The lower level applies to low-level milk recorder jars and low-level milk pipelines. The operating vacuum level should always be constant during milking with all units in use and compared with the control mercury vacuum gauge, it should never exceed 2 kPa (1.5 cm Hg). If there is a great difference then most likely there is something wrong with the vacuum pump, there are leaks in the system or the vacuum regulator is not functioning properly.

Regular testing of milking equipment is a must!

How is testing performed
For a reliable test result it is necessary to place a T-piece between the interceptor (moisture trap) and the vacuum regulator on the vacuum pipeline. The T-piece must have the same pipe diameter as the vacuum pipeline connected to the vacuum pump and is used for connecting a test pipe. On the test pipe an air-flow meter and a calibrated control vacuum gauge or a mercury vacuum gauge must
Air consumption of components and vacuum reserve capacity

For measuring the air consumption and reserve capacity, the airflow meter with an adjustable tap is used. The air consumption of the individual components is measured by comparing the air consumption with and without that particular component. The reserve capacity is the amount of air measured when all components are working at a vacuum of 2 kPa (1.5 cm Hg) lower as the working vacuum. This is necessary in order to measure the air consumption of the various components, such as pipeline system leakage, cluster air admission, automatic cluster removal equipment, pulsator air requirements, regulator leakage, and the vacuum reserve capacity. All these values are expressed in litres of air per minute and must be compared with the standard values.

The vacuum requirements depend on: the number of milking units, the number of recorder jars, length and diameter of the vacuum pipeline, and length and diameter of the milk pipeline. Most milking machine manufacturers supply a specification chart for their equipment. Examples for the recommended minimum free air capacity in litres per minute of the vacuum pump and number of units at sea level are given in table 2 of Milking Machine Management, volume 1. The vacuum pump capacities are also influenced by geographic altitudes and the capacity must be adjusted as well according to table 3 in Milking Machine Management, volume 1.

The standards for minimum air reserve capacities in litres per minute of different types of milking machines with number of units in use are listed in table 1 in this manual.

Air resistance in the vacuum pipelines
All milking units and vacuum-consuming parts should be in operation to measure the difference in vacuum between the beginning and the end of the vacuum pipeline with the calibrated control vacuum gauge. The difference in vacuum must not exceed 2 kPa.

Pulsation characteristics
A vacuum recorder is essential for examination of the characteristics for the pulse applied and the rapid changes of vacuum within the pulsation system. The vacuum connection of the recorder is attached to a plastic T-piece inserted in the short pulse tube of the cluster assembly and consequent.

| Table 1 Minimum air reserve capacity of the vacuum pump in litres per minute by number of units. |
| no. of units | bucket type | milk pipeline type |
| 4           | 180 l./min | 320 l./min   |
| 6           | -          | 380          |
| 8           | -          | 440          |
| 12          | -          | 520          |
| 16          | -          | 560          |
| 20          | -          | 600          |
quently the mouth of the liner must be closed with an artificial teat.

The readings obtained by the vacuum recorder indicate the pressure changes between the liner and the shell, so working vacuum (milk phase) with atmospheric pressure (rest phase). For alternate pulsations a separate recording must be taken for each pair of teatcups. Some milking machines have pulsators which run at a 50:50 ratio, while others remain longer in the milking phase, such as 60:40, 70:30, etc. Normally, pulsators operate in the range of 50-65 cycles per minute. The values of the ratios obtained and the number of pulsations should not deviate more than 5% from those recommended by the manufacturer. The limping of alternating pulsators must be less than 5%.

For proper functioning of the pulsator it is of utmost importance to maintain a stable vacuum to avoid irregular pulsations. Regular and thorough checking of pulsators contributes to better milking performance.

The state of maintenance of all other components

All other components involved in milking should be checked visually and, if necessary, be replaced, such as worn seals and gaskets, leaking taps, drain valves, etc.

STORAGE AND COOLING OF MILK

The dairy farmer is responsible for milk produced at the farm up to the point where it is collected. Milk is a product that can easily be contaminated with bacteria, odours from certain feeds and chemical impurities. The purpose of good storage and cooling of the milk soon after production is to keep the milk bacteria at a minimum level before processing for milk consumption or daily product manufacture. The dairy farmer is only able to deliver high-quality milk, if:

• he maintains a high hygienic standard within the barn and during milking;
• he succeeds in keeping the initial (low) number of bacteria in the milk at a minimum level through good milking practice and proper cleaning and disinfecting of all milking equipment;
• he cools the milk at the farm immediately after milking;
• he takes the milk to the collecting point/dairy plant as soon as possible after milking;
• he maintains his milking machine in optimal working order.
Storage of milk can be done in milk cans or in a refrigerated milk-storage tank. If the milk remains at the farm for over 24 hours it is recommended to have a bulk milk tank on-site. The milk storage temperature of 4°C must be reached within 3 hours after milking, but preferably quicker. The ISO recommends that milk cooling tanks should cool 25 percent of the milk tank contents from 35°C to 4°C within 3 hours at an ambient temperature of 25°C. Use table 2 as a guideline.

There is an important relationship between the storage temperature and the bacterial growth in raw milk. Table 3 shows the quick multiplication of bacteria at higher storage temperatures.

### Table 2: Recommended storage temperatures at different storage times.

<table>
<thead>
<tr>
<th>Storage time</th>
<th>Storage temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 12 hours</td>
<td>12°C</td>
</tr>
<tr>
<td>12 - 24 hours</td>
<td>8°C</td>
</tr>
<tr>
<td>24 - 72 hours</td>
<td>4°C</td>
</tr>
</tbody>
</table>

Cooling water basin
Cold tap or well water is brought into the basin under pressure through a small inlet at the bottom of the basin. The "used" water disappears through an outlet at the upper edge of the basin. Regular stirring of the milk will increase cooling efficiency.

Surface ring cooler
Cold water, distributed under pressure through tiny holes in tube rings (placed around the neck of the milk cans) cools the surface of the cans. It is advisable to

### Table 3: Bacteria count per millilitre of milk at different temperatures.

<table>
<thead>
<tr>
<th>Milk storage for 24 hours at</th>
<th>Bacteria count per ml.</th>
</tr>
</thead>
<tbody>
<tr>
<td>4°C 39°F</td>
<td>2,500</td>
</tr>
<tr>
<td>5°C 41°F</td>
<td>2,600</td>
</tr>
<tr>
<td>6°C 43°F</td>
<td>3,100</td>
</tr>
<tr>
<td>10°C 50°F</td>
<td>11,600</td>
</tr>
<tr>
<td>20°C 68°F</td>
<td>450,000</td>
</tr>
<tr>
<td>30°C 86°F</td>
<td>1,400,000,000</td>
</tr>
</tbody>
</table>

Cooling of milk stored in milk-cans
Milk stored in milk-cans is normally cooled indirectly by tap or well water. In many cases it is necessary to use chilled water. Milk-cans should be stored in insulated rooms to minimise reheating during storage at the farm. To achieve quick cooling with water, the water temperature must be 3°C lower than the required milk temperature before delivery/collection. In warmer climates this might be difficult and therefore chilled water must be used. The following methods can be used for cooling milk in cans:

- a cooling water basin
- a surface ring cooler
- a charcoal evaporative cooler
- a corrugated surface cooler
- an in-can turbine milk cooler

Proper cooling is an important link between the cow’s milk production and the delivery to the dairy factory.
stir the milk regularly to increase cooling performance of the milk.

For the cooling water basin and the surface ring cooler, the amount of water required for cooling is about 5 times the quantity of milk stored in the cans.

A good airflow around the cooler will improve the cooling efficiency. A water container placed inside the cooler will increase the rate of cooling. Although not an ideal system, it will, nevertheless, enable small milk producers to extend the storage period.

**Corrugated surface cooler**

Another simple method of milk-cooling in small dairies is to use a surface cooler. This cooler consists of two corrugated 'curtains' with a water channel in between. The milk flows down the outside surfaces, with chilled water running in the opposite direction through the inside. By the time the milk reaches the bottom it has been sufficiently cooled. The rate of milk flow should be correctly regulated as well as the milk’s following the line of corrugations. The inlet water pipe should be coupled either directly to a piped cold water supply or to a header tank with chilled water.

**In-can turbine milk cooler**

The in-can turbine cooler is placed in position on a milk can. Chilled water passes through the stirrer tubes and leaves them through tangential jets at the top. The water pressure causes the rotor inside the can to turn. These coolers are capable of cooling 50 l of milk from 35°C to within 3°C of the mains water temperature in about 15 minutes, using about 175 l of water in the process.

When it comes to cooling efficiency for small amounts of milk, the corrugated surface coolers and the in-can turbine coolers are the most successful. They are popular for their low investment cost.

**Charcoal evaporative cooler**

In areas where water is a scarce commodity the evaporative cooler offers a partial solution for cooling small quantities of milk. This system works on the principle of water trickling over a porous material (charcoal), resulting in evaporation and cooling of the surrounding air. If the air to be cooled is confined within a room it is possible to cool that air to between 10°C and 15°C below the outside temperature. Low humidity and a good airflow around the cooler will improve the cooling efficiency. The collection of the stored milk before being transported to the dairy factory

**Cooling of milk in refrigerated farm milk storage tanks**

In view of the ever-increasing sizes of herds, it is important to plan ahead and purchase a milk storage tank large enough to allow for herd expansion. Most dairy-processing plants recommend that a tank be of a size to hold at least five milkings so that every-other-day pickup is possible, and an extra milking can be held in case of an emergency. Beside this, many dairy-processing plants offer premiums to dairy farmers...
farms for collecting big milk loads. The most important reason for rapid cooling of larger amounts of milk is to preserve its quality. However, there are other significant advantages of cooled milk in bulk tanks for milk producers and processing plants:

- cooling permits bulk collection once a day, every second or third day, depending on the milk storage tank capacity and the quantity of milk produced;
- the time required to collect bulk milk is reduced and the heavy work of milk can handling is omitted;
- there is less risk of rejection of milk due to bacterial deterioration;
- the producer can be assured of maintaining a uniform quality throughout the year, and will thus be eligible for premiums paid for quality milk.

Modern cooling equipment will cool milk rapidly to about 4°C and allow storage of milk for a longer period of time. These coolers must all be made of stainless steel and have polished interiors to ensure that the equipment can be easily cleaned.

Many dairy farms with large milk storage tanks and where milk production yields are high, find that pre-cooling equipment is quite practical and therefore use a plate cooler. The principle is the same as that of the corrugated design, but the cooling surface is much larger. Forcing milk through a plate cooler creates considerable turbulence which adds to its cooling efficiency. A smaller refrigeration unit is required and milk temperatures can be brought down quickly before the milk is brought into the storage tank. Plate coolers of sufficient capacity are extremely efficient. Depending on the temperature of the water and the milk and water flow rate, the milk temperature can be lowered as much as 25°C. The water used for cooling with this system is significantly raised in temperature and can be used for udder washing and other purposes.

Refrigerated bulk tank coolers
There are two types of refrigerated bulk milk tanks; the direct expansion and the indirect expansion or ice bank milk tank. The refrigeration system used in bulk milk tanks is the same as that used in domestic refrigerators and deep-freezers. Milk stirring is an integral part of the cooling system.

- direct expansion milk tanks
In most direct expansion milk tanks the evaporator coil is an integral part of the wall of the milk tank which directly cools the milk through heat extraction. Direct expansion cooling seems to work more quickly than indirect expansion cooling.
• **indirect evaporation or ice bank milk tanks**

In indirect expansion systems the evaporator coil is immersed in a water bath, whereby ice builds up on the coils over a longer period of time. The ice on the coils melts during the milk-cooling process. Indirect expansion coolers have the advantage that an amount of ice can be made at any time of the day outside milking hours and use where cheap electricity from the mains is available.

**Immersion coolers**

For small farms the immersion cooler may be the solution. These units can be used for direct cooling of milk in cans or in stationary or mobile tanks. The mobile tank is particularly useful if road conditions are unfavourable for big bulk milk lorries. The principle of cooling is the same as that of the in-can turbine cooler.

**HEAT RECOVERY SYSTEMS**

As described earlier, a substantial amount of heat is released during the process of milk cooling. This heat can be used for warming up water. The heated water can directly or after additional heating to a pre-set temperature in a boiler of an adequate size, be used for cleaning the milk pipeline, the milk storage tank and eventually udder-washing purposes.

In the heat recovery systems the compressor of the refrigeration milk tank or plate cooler in fact acts as a heat pump. With the assistance of a heat pump and dependent on the system in use, about 0.3 to 0.8 litres of warm water of a temperature of about 55°C can be produced per litre of milk. The application of a heat pump can result in a considerable saving on energy costs of about 50% for heating up water to the required temperature for cleaning purpose. With a view to the possible growth of the *legionella* bacterium it is recommended to heat up this water to a temperature of above 60°C.

The economic value of heat recovery systems depends mainly on the initial costs of investment, the quantity of hot water required for all purposes and on the quantity of milk to be cooled. If more milk is cooled, more heat comes available. It is recommended that the economics of heat recovery systems be investigated on an individual on-farm basis.

---

*Hygienic milk production starts with clean udders*
SUMMARY

The sound working of your milking machine depends largely on good care and the maintenance of your milking installation. To ensure a better-quality milk product, rapid cooling to about 4°C is necessary to slow down the growth of bacteria. Your choice of cooling equipment should depend on the quantity of milk produced and the availability of water and electricity.

The general guidelines for milking machine management are:

1. following the recommendations of the ISO for milking machine testing;
2. having a vacuum pump with sufficient air reserve capacity;
3. properly functioning vacuum regulator;
4. maintaining a stable working vacuum of the milking machine;
5. regular checking of the pulsation rate and ratio;
6. keeping your milking machine in optimal working order under all circumstances;
7. storing and cooling the milk within cans or properly designed milk tanks;
8. considering pre-cooling before storage of large quantities of milk;
9. achieving quick cooling at 4°C within 3 hours after production to slow down bacterial growth;
10. taking out a periodic maintenance and service contract with your dealer.
FURTHER REFERENCES


Earlier publications:

- Reproduction Management
- Young Stock Management
- Foot Care Management
- Feeding Management, Volume 1
- Feeding Management, Volume 2
- Milking Machine Management, Volume 1
Dairy Training Centre Friesland (DTC-Friesland) is established by various Dutch farmers’ organisations and controlled by the Ministry of Agriculture. The Centre conducts a variety of international training programmes and courses. We also provide consultancy and management services.

All courses have a strong practice-oriented character based on the training concept of **learning by doing**. The practical training is very intensive; one instructor deals with groups of six students and for subjects like milking even with three students only. DTC-Friesland offers training in the following subjects:

- **Dairy Husbandry**
  - machine- and handmilking, milking machines, milk hygiene
  - feeding, ration calculation, feedplans, quality of feedstuffs
  - fertility management, heat detection
  - breeding, use of A.I., culling, body conformation
  - housing, tying/cubicle systems, hygiene
  - health, mastitis control, hoofcare
  - calf rearing
  - farm economics
  - farm administration

- **Forage production**
  - pasture management
  - fodder crops
  - silage making
  - farm machinery

- **Milk processing**
  - manufacture of cheese, butter, yoghurt, ice-cream, etc.
  - milk collection and payment systems
  - marketing
  - management of a dairy unit

- **Sheep husbandry**
- **Dairy goat husbandry**
- **Intensive beef production**
- **Horse keeping and animal traction**
- **Teaching methodology**

Visits to farmers’ organisations, A.I.-stations, Health and Extension service etc. are integrated in the courses to provide a good picture of the dairy sector in the Netherlands.
AD HOC COURSES
Our major activity is the organisation of ad hoc courses on request, preferably for groups of a multiple of six participants. These training programmes are tailor-made and completely designed according to the requirements of the client. The courses deal with one or more of the earlier mentioned subjects. Duration of the courses varies from 1 week to several months. The courses are conducted in English. For some special subjects training can be provided in French, Spanish or German as well. If facilities are available locally, our staff is prepared to conduct courses abroad as well.

SIX-WEEKS COURSE: MODERN DAIRY FARM MANAGEMENT
This course is especially designed for persons in charge of a large-scale dairy enterprise, and includes all aspects involved in managing a dairy herd. The course offers a good opportunity to refresh one’s knowledge and learn about recent developments in dairy farm management. The course is conducted annually in September/October. However, for groups of at least six persons it can be organised at any time during the year.

TRAINING FACILITIES AND STAFF
The centre has four farms, each with a different management system. One farm is especially equipped for international courses. The total stock at the four farms includes 250 dairy cows, 50 fattening-bulls, 45 dairy goats, 85 sheep and 12 Friesian horses. Additionally, the centre maintains close relations with twenty neighbouring farms which are used for practical training. Our staff consists of fifty dedicated and well-qualified trainers. All have up-to-date knowledge of modern dairy farm management, and over 70 man-years experience is present in various dairy development projects throughout the world.

ACCOMMODATION
A newly constructed hostel provides full board and lodging in single or double bedrooms. The hostel provides an international kitchen, and many recreational facilities. Social excursions are organised during the weekends to enable the students to get acquainted with the Dutch culture.

For more detailed information on the activities of DTC Friesland, please contact:

Dairy Training Centre Friesland
P.O. Box 85
9062 ZJ Oenkerk
The Netherlands

Telephone : +31 510361562
Telefax : +31 510361628
Telex : 46838 dtcfr nl
TOP MANAGEMENT . . .

. . FOR THE BEST RESULTS

VEEPRO HOLLAND
Information centre for Dutch cattle